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SVIC NOTES

The On-Orbit Environment

Since the first U.S. space shuttle launch, more thought has been given to space stations and other large orbiting space structures. We are now entering a new era in shock and vibration. The design and testing of the new breed of large space structures presents a new set of dynamic problems to be dealt with.

First is the question of materials properties. Today, there are many new composite materials available to the aerospace design engineer, such as metal-matrix, graphite-epoxy, and Kelvar-epoxy. The damping properties of many of these composites aren't available, even from the manufacturers. And, even if there are damping data available on coupon or beam samples, there is the question of the usefulness of this data in the prediction of the modal damping of a built-up structure where the damping in the joints exceeds the inherent material damping.

Second is the problem of weightlessness. The new structures are designed to be constructed or deployed in space. Some are so flimsy that they won't even support their own weight on earth. How, then, can a modal or a vibration test be performed on these structures? One technique is to use scale models which are dropped in large vacuum chambers or flown in parabolic trajectories in aircraft to simulate the zero-g environment. Other ground-based techniques have been developed where the spacecraft is hung from bungee cords or springs to simulate the zero-g environment. All of the earth-bound techniques have problems associated with them, however, which may make their results invalid. The measured value of the stiffness of a structure suspended from soft springs is the property most suspect. Gravity causes individual structural members to sag which reduces the stiffness of the structure. Also, the stiffness across joints in deployable panels is affected by gravity. In a recent space shuttle flight, the stiffness of the solar panel which was deployed in the cargo bay was much higher than the predictions!

To summarize, I suggest new techniques will have to be developed to qualify these structures for the on-orbit environment. Such techniques might include sophisticated scale model tests, more powerful analytical prediction methods, and in-orbit testing of structures such as the solar panel flown on the shuttle. Also, more work needs to be done to tabulate the available data on the damping properties of the newer composites materials.

JGS

EDITORS RATTLE SPACE

TECHNICAL MEETING CONTENT

Each year thousands of engineers attend technical meetings for the purpose of obtaining new knowledge and experience. The content of these meetings ranges from theory to tutorial including workshops which provide an exchange of experience. Specifically, engineers go to meetings to present or listen to theoretical or applied research results, participate in workshops where experiences and results are exchanged, and/or learn fundamentals and techniques in tutorial sessions.

Except for some specific instances which I shall address, it appears that the attendance at meetings has declined in recent years. Is this trend the result of economic pressures; or, is it result of technical meeting content? While economic pressures do exist and do influence the number of engineers involved in external training and education, I maintain the decline in technical meeting attendance is a result of the content. The lack of new significant research results has made it difficult to justify meeting attendance -- even if a paper is being published. The development of new techniques has reached a plateau. New test data and design techniques are rarely presented. Then why does an engineer attend a conference or meeting today?

The most successful meetings today involve the exchange of experiences and results derived from hardware oriented problems. In these meetings the difficult to obtain experiences (not usually recorded in journals and magazines) are discussed in detail. The difficult art of engineering is exchanged. Engineers save years of frustration on how to solve a difficult problem in a simple manner; or, an understanding of a little known phenomenon is obtained. It has been found that these workshops save millions of dollars each year through direct exchange of experiences.

Thus it appears that certain types of meetings have been successful in the last few years. It is because they continue to fulfill their mission of providing useful information exchange -- mainly by workshops. It appears that this mechanism would work at almost every level of the technical meeting and it is questioned why the mechanism is not more frequently utilized.

R.L.E.

ON SEISMIC WAVES

Sasadhar De*

Abstract. *The article on seismic waves deals with various aspects of the propagation of elastic waves on Earth, mathematical methods, waves due to explosion and oscillation of the Earth, seismic prospecting, seismic risk, ground motion and structures, and mechanisms and prediction of earthquakes.*

This article is a continuation of two previous reviews [1, 2] published in the Digest. Surface and guided waves, mathematical methods, waves due to explosions and oscillation of the Earth, seismic prospecting, seismic risk, and related problems are discussed.

SURFACE AND GUIDED WAVES, MATHEMATICAL METHODS, MODELS

Theories of elastic wave propagation in fluid and solid layered media [3] and in bodies with initial stresses [4] as well as wave motion in anisotropic and cracked elastic media [5] have been reviewed. The propagation of surface waves in marine sediments [6], in anelastic media [7], and in a heat-conducting elastic body [8] have been studied. Characteristics of the propagation of Rayleigh waves through irregular structures [9], of Love waves through laterally heterogeneous structures [10], and of plane harmonic waves in wet granular media [11] have been discussed. The ray theory plays an important role in problems of layered media [7, 12]. A generalized ray theory has been developed to study transient SH-waves in a wedge-shaped layer over a half-space [13].

Channel waves serve as a tool for the detection of discontinuities in coal seams caused, for example, by tectonic faulting; Love waves propagating along discontinuous coal seams have been studied [14]. The dispersion relations for Love channel waves have been derived [15]. A numerical model of SH-type channel waves has been presented [16] and utilized to derive a recompressing filter to remove dispersion of the waves. Oceanic acoustic and seismic disturbances have been modeled as Rayleigh-Stoneley waves in a layered medium consisting of ocean, sediment, and rock [17]. The bulk waves observed in longitudinal profiles of layered media have been divided into symmetric and antisymmetric waves; specific features of the wave twins have been discussed [18]. An acousto-elastic effect for the Rayleigh surface wave [19], a secular equation for Rayleigh waves on the surface of an anisotropic half-space [20], group velocity dispersion curves of Rayleigh waves [21], and dispersion of leaky compressional (PL) waves [22] have been studied.

A solution has been considered to the variance equation for P waves in a soft medium with electrokinetic properties [23]. Rayleigh's principle and the concept of local wave number have been utilized to determine the dispersion of Love waves [24]. Surface SH waves in nonhomogeneous media [25], dispersion-free waves in a medium with a cylindrical cavity [26], and Rayleigh-wave propagation on a gravitating spherical earth [27] have been studied. Rayleigh and Love waves in an irregular soil layer have been analyzed [28]. Solution of a seismic migration problem by Fourier transform in the wave number and frequency domain has been presented [29].

Wave processes in real crystals [30] and in weakly anisotropic media [31] have been described. A solution of coupled elastic-gravitational field equations has been studied [32]. Wave propagation along a plane boundary separating compressible, previously deformed bodies with elastic potential of arbitrary form has been considered [33]. P-wave propagation in anisotropic solids has been examined [34]; the effect of anisotropy on the polarizations of quasi-

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P waves was determined. Surface waves in an isotropic linear elastic half-space with plane material (boundary) [35], free boundary waves at a plane interface between a half-space and a compressible nonviscous liquid [36], and normal wave propagation through an unbounded material that is mildly stratified or periodic [37] have been analyzed.

An edge wave traveling along a continental shelf with a sloping region sandwiched by a flat shelf and an ocean bottom has been investigated [38]. A model experiment has been performed to investigate Rayleigh waves transmitted across a trench [39]. Characteristics of surface-wave propagation in an ocean basin have been examined numerically [40, 41]. A stochastic perturbation theory has been used to study the propagation of plane seismic waves in a medium in which random fluctuations in local density and elastic shear modulus were considered [42]. Surface-wave distribution along the plane boundary of a fluid and a prestressed body interface [43] as well as shear modes in a system consisting of a liquid and a prestressed half-space [44] have been examined. Propagation of Rayleigh and Love waves in a multilayered nonhomogeneous viscoelastic half-space has been studied [45].

Conditions under which the equations of motion in a nonhomogeneous isotropic medium can be approximated by the scalar wave equation, and under which the scalar wave equation can be approximated by a ray equation, have been discussed [46]. The discrete wave number method has been used to study motions due to an arbitrary tensile source [47]. A model for a strike-slip fault has been proposed in which an instability such as an earthquake or stable fault slip has been produced by strain softening of the fault zone [48]. A method to obtain the displacement field of a Haskell model of an earthquake source, based on the well-known equivalence of seismic dislocations and body force, has been described [49]. A model, based on fracture mechanics concepts, of the behavior of an earthquake source prior to the occurrence of an earthquake has been presented [50]. Disturbances in a medium due to torsional motion of a circular ring source [51] and transient forces and twists on the surface of a spherical and a buried cylindrical source have been studied [52]

An unstable constitutive model has been constructed to represent a fault medium [53]. A general constitutive equation of an elastic-plastic rock medium was used; the coefficient of internal friction and cohesion of the fault medium were assumed to vary with deformation. Teleseismic P_n waves have been modeled as a sum of whispering gallery waves [54]; these waves propagate in a waveguide composed of a simple high-velocity mantle lid underlain by a low-velocity zone. A plane-geometry model has been used to illustrate the effects of a fluid confined in a bore hole on surface and body waves traveling along the bore hole in an elastic solid [55]. The effects of a contacting layer and oscillation polarization on transverse wave propagation along a nonrigid contact between identical half-spaces has been considered [56].

The propagation of energy in half-spaces with the passage of a Stoneley wave [57] and the behavior of a non-steady surface wave in a nonhomogeneous linearly deformable elastic medium [58] have been studied. A numerical approach to surface-wave propagation across vertical discontinuities has been discussed [59]; computational results for Love wave propagation across the vertical boundary between two layered-quarter spaces were demonstrated. A pair of semi-linear hyperbolic partial differential equations governing slow variations in amplitude and phase of quasi-monochromatic finite amplitude Love waves on a layered half-space has been derived [60] using the method of multiple scales. The behavior of waves in a nonhomogeneous composite medium with after effect has been studied [61].

The effect of initial stress on the propagation of Love waves has been examined [62], as has the same problem in a half-space with a double superficial layer [63]. The propagation of such waves in nonhomogeneous layers lying over a prestressed half-space has also been demonstrated [64]. Seismic radiation from an arbitrarily growing spherical source in a nonhomogeneously prestressed medium [65] has been analyzed.

The propagation of seismic phases P_n, P_g, S_n, and L_g from earthquake and explosion sources [66] and of seismic waves in the Earth's crust [67] has been studied. The propagation of shot-generated Stoneley waves as well as ambient background noise [68] have been discussed; Stoneley waves were observed propagating at velocities of 20 to 50 ms^{-1}. Fundamental mode Love and Rayleigh waves generated by some

earthquakes have been analyzed [69]; the dispersion of such waves has been used to determine models of shear velocity against depth for crustal ages [70]. The group velocity dispersion characteristics of fundamental mode Rayleigh waves (T = 20 to 100 sec) have been determined from moving window analyses of seismograms [71].

A solution for surface displacements due to buried dislocation sources [72], formulas for calculating travel times in transversely isotropic Earth models [73], equations describing the relation between pressure and wave-propagation velocity in fracture and porous rock [74], and equations of motion describing the linear magneto-elastic behavior of a continuum [75] have been considered. The problem of crack propagation [76] as well as seismic waves and the spectrum generated by a dynamical rupture process [77] and displacement spectra from micro-earthquakes [78] have been studied. A perturbation method has been used to study the effect of weak nonhomogeneities on the propagation of seismic rays through a layer of fixed thickness [79].

The Airy function often appears as a part of solutions in theoretical seismology [80]. The range of problems in applications of statistics to seismology has been surveyed [81]. An analytic solution of the problem of propagation of a longitudinal sinusoidal wave has been considered [82]. Wave-induced stress in a porous elastic medium has been studied on the basis of Biot's linearized theory [83]. Finite difference techniques have been used to study the response of a sedimentary basin in an isotropic half-space to vertically incident compressional and shear sources [84]. Displacements on the surface of a traction-free half-space have been studied [85, 86].

The splitting matrix method has been used [87] to derive two parabolic-approximation partial differential equations to a three-dimensional linear wave equation nonhomogeneous media. A numerical technique for attaining the SH-wave contribution to tangential displacements due to point dislocation sources in a plane layered Earth has been shown [88].

The behavior of Green's functions for Biot's equation in the neighborhood of wave fronts has been discussed [89]. A method to derive the coefficients in the strain energy functional of Biot's theory for elastic waves in fluid-saturated porous media has been proposed [90]. For a stratified elastic half-space Green's tensor has been used to give a spectral representation for coupled seismic waves [91]. The finite element method has been used to obtain a dispersion curve for fundamental-mode Love waves [92].

A scalar potential representation for a P wave in a nonhomogeneous medium has been developed from ray theory [93] and shown to be applicable to both P and S waves. Spontaneous cracks spreading over a fault plane in an infinite medium have been studied as an earthquake source model [94]; the boundary integral equation technique was used. The Somigliana dislocation theory has been applied [95] to the study of strike-slip faulting in an isotropic, homogeneous half-space in the presence of localized distributions of strain nuclei.

Equations governing the propagation of random Rayleigh waves in isotropic viscoelastic solids have been derived [96]. The propagation of elastic spherical waves emitted by a source point placed outside a given finite set of concentric spherical layers has been studied in an infinite space [97]. Green's functions for a layered medium can be expressed as a double integral over frequency and horizontal wave number; the wave number integral can be represented by a discrete summation [98]. An equation for waves on an anisotropic half-space has been examined [99]. Partial derivatives of Love wave phase velocities with respect to shear velocities in a spherical Earth have been computed [100].

The theory of micropolar continua has been used to study some earthquake problems [101]; changes in Earth's inertia tensor due to earthquake faulting have been calculated using a reciprocal relation. The frequency equation of Rayleigh waves in a thermo-elastic half-space under initial stresses [102], the influence of gravity on wave propagation in a thermo-elastic layer [103], a Rayleigh wave velocity equation in a micropolar medium with stretch [104], and propagation of magneto-elastic Love waves [105] have been discussed. The solution for a problem of connected thermo-elasticity on surface wave propagation in the isotropic half-space formed by regular alternation of several layers with different thermo-mechanical properties [106] has been studied. The damping and dispersion of Rayleigh waves by the

Dyson-equation method (which is used in quantum field theory) have been analyzed [107].

The existence of a periodic progressive wave solution to the nonlinear boundary value problem for Rayleigh surface waves of finite amplitude has been demonstrated using an extension of the method of strained coordinates [108]. The Cauchy problem for a system of first-order nonlinear ordinary differential equations describing the propagation of rays in a nonhomogeneous medium has been considered [109]. Nonlinear mode coupling between two co-directional quasi-harmonic Rayleigh surface waves on an isotropic solid has been analyzed [110] using a method of multiple scales. A solution has been obtained for a nonlinear differential equation that describes an initially sinusoidal finite-amplitude elastic wave propagating in a solid; the solution contains a static displacement term in addition to the harmonic terms [111]. An experimental study of the elastic-wave static displacement in a solid was also considered.

HEAD WAVES

When a half-space $z > 0$ is subjected to a point load or source of disturbance, energy will reach the interior in two ways: by flux along rays emanating directly from the point of excitation and by paths consisting of a line segment in the free surface and radiation into the interior from each point of such segments. The most significant secondary radiation from the surface is due to the passage of the fastest wave front over the surface. The associated stress vector on the plane $z = 0$ is, in general, nonzero. The stress-free condition on $z = 0$ will require generation of an equal and opposite stress vector by displacement components other than the polarization vector of the fastest wave front.

The displacement components resolved along the polarization vectors of slower waves propagate to the interior. Constructive interference of such secondary radiations gives rise to loci of constant phase (wave fronts) known as head waves. The properties of such waves in anisotropic elastic media have been discussed [112-115]. For a layered structure sandwiched by two half-spaces, the dynamic properties of head waves propagated along some interface that interferes with reflected waves or head waves along other interfaces have been investigated by calculating their theoretical seismograms [116]. The uniqueness of the solution has been proved for an inverse kinematic problem for seismic head waves [117]; the waves were propagating in a medium with a curvilinear boundary at constant velocities according to a system of two oncoming time curves with unknown velocity in the upper layer.

OTHER PROBLEMS

The reflection and refraction of elastic waves at a plane interface between two (initially stressed) solid media in contact [118] and of general plane P and type - 1 S(SV) body waves incident on plane boundaries for general linear viscoelastic solids [119] have been discussed. The effects of an inclined interface on the reflection and refraction of Rayleigh waves have been analyzed by the method of Green's function [120]. The reflection, refraction, and absorption of obliquely incident plane harmonic anti-plane strain (SH) waves at a frictional interface between dissimilar semi-infinite elastic solids [121] have been studied, as have the reflection and transmission of P and SV waves at the Earth's core-mantle boundary (under initial stress) [122] and of long sinusoidal tsunami waves [123]. The pattern of amplitudes of a reflected-diffracted wave train has been found to depend on the dimensions of the fracture zone [124].

The diffraction of anti-plane shear waves by a Griffith crack or a rigid strip [125], and by an edge crack [126] have been investigated, as has the diffraction of Love waves by a stress-free crack of finite width [127]. Diffraction of SH waves by a spherical stratified medium [128] and normally incident SH waves by a rigid strip [129] have been discussed. The diffraction problem associated with the propagation of plane harmonic Love waves [130] and low frequency diffraction of a plane harmonic shear (SH) wave by an edge crack in a wedge of arbitrary vertex angle [131] have been considered. The diffraction and scattering of elastic waves by a smooth or slightly rough solid-liquid interface [132], with application to the core-mantle boundary, and of SH waves by surface irregularities [133] have been studied.

The scattering of Rayleigh waves in an elastic quarter space [134], in a rectangular rough surface [135], at

a trench ditched on the surface of an elastic half-space [136], and by corrugations (grooves and ridges) for an arbitrary angle of incidence [137] has been considered. The Born approximation has been used in seismic scattering problems [138]. Scattering of elastic waves from a fluid-filled cavity [139] by an inclusion embedded in an infinite homogeneous medium [140] and by a three-dimensional non-homogeneity in a half-space [141] has been studied.

The scattering of obliquely incident P and SV waves by an infinite rigid elliptic cylinder [142] and of plane harmonic SH, P, SV, and Rayleigh waves by several inclusions of arbitrary shape [143] has been investigated. Multiple scattering from cracks in two-dimensional plane-strain conditions [144] has been discussed, as have scattering of SH waves by subsurface circular cavities and thin slits [14] and scattering of waves through a crust and upper mantle with random lateral and vertical nonhomogeneities [146].

Early precursors to PP' have been reinterpreted as waves scattered on an underside reflection at the core-mantle boundary [147]. The scattering and attenuation of shear waves in the lithosphere have also been studied [148].

Attenuation of waves due to multiple scattering from inclusions [149], in a random anisotropic two-phase medium [150], and in a material containing cracks [151] has been discussed, as has attenuation of Love and Rayleigh waves across the Atlantic ocean [152]. Expressions for attenuation by means of a stochastic perturbation technique [153] using random wave propagation theory, an intensity attenuation equation [154], and an attenuation coefficient for a Rayleigh wave propagating along a corrugated surface of crystals of cubic and hexagonal symmetries [155] have been derived. The specific dissipation factor Q^{-1} of rocks containing small amounts of volatile material has been determined [156], as has the Q-value using amplitudes of first P arrivals recorded at many stations [157].

Mantle creep and attenuation, viscoelastic behavior of rock, and body waves have been discussed [158]. The structure of the mantle beneath the East European platform [159] has been analyzed. Thermodynamic properties of the Earth's lower mantle [160], rheological properties of the upper mantle [161], and seismic discontinuities in the mantle [162] have been studied. Investigations of the Earth's interior that require the application of high-pressure research have been considered [163]. A model to explain the generation of earthquake lights has been proposed [164]. The occurrence of double seismic planes beneath some island arcs has been explained [165] in terms of an unbending of the descending lithosphere; the temperature at double seismic zones in the descending lithosphere was estimated. Variations in the stress field of the Earth's crust due to lateral variation in thickness and in temperature [166] have been analyzed. A basic nonhomogeneity of the upper mantle [167] and mantle velocity distribution [168] have been considered. Compressional and shear wave velocities have been measured [169] in a cubic anvil apparatus up to 700°C at 6 kbar in igneous and metamorphic rocks typical of the crust and mantle. The equation of state has been applied to high-pressure and high-temperature states of geophysically relevant substances [170] and to the Earth's lower mantle [171].

Problems of seismological instrumentation have been discussed [172]. A device capable of automatically recording a number of bursts of acoustic emission from rocks has been developed [173]. The basic design of a handy, compact, maintenance-free seismograph [174] has been described. A practical algorithm for the detection of S-wave arrivals has been considered [175]. A laser interferometer has been developed to study the displacements and oscillations of the Earth's crust [176], as has an acoustic interferometric technique to measure ultrasonic velocity and attenuation in rock melts [177].

A method for rapid retrieval of earthquake-source parameters from long-period surface waves has been described [178]. An instrument to study changes of frequency, temperature, and pressure has been considered [179]. Down-hole logging methods as applied to uranium exploration have been described [180]. The soil-gas Rn value has been measured [181] in various ways: by two types of alpha-particle track detectors, by emanometry, and by counting alpha activity on Rn decay-product collectors.

A variable $R = K_f/K_s$ has been defined [182] in strain softening earthquake models, that will measure the degree of earthquake instability (K_f = stiffness of the fault zone, K_s = stiffness of the elastic surroundings);

instability occurs when increasing R reaches unity. A classical pulse-propagation problem in geophysics has been used to demonstrate a technique of the differential transform over that of Cagniard [183]. Adaptive prediction has been applied [184] to detect small seismic events in microseismic background noise.

WAVES DUE TO EXPLOSION

The seismic waves from large explosions [185] have been studied, and source models for underground nuclear explosions have been reviewed [186]. Low-frequency components of the near-field ground motions [187] produced by surface explosions and Rayleigh waves from atmospheric explosions [7] have been discussed. The kinematic and dynamic parameters of transverse waves resulting from explosions have been analyzed [188], and the P- and S-wave velocity variations from some explosions [281] have been determined.

The waves generated by explosions have been studied for the crustal structure in the western Kanto district [190]. Ground shock propagation in a layered Earth produced by near-surface airburst explosions has been considered [191] using Cagniard elastic propagation theory. Formal solutions for ocean bottom disturbances due to underwater explosions have been derived using the Haskell matrix formulation [192]. A nonstationary model has been proposed [193, 194] for seismic records of P waves from underground nuclear explosions and natural earthquakes.

The teleseismic P-wave travel-time residuals of shallow earthquakes and nuclear explosions [195], the propagation of signals from an underground source through a seismically active zone [196], and the radiation of waves during an explosion in a porous medium [197] have been studied. Surface-wave observations from underground explosions have been attributed to the phenomenon of spall [198]. Spectral analysis of explosion earthquakes associated with single eruptions of the Asama Volcano in 1973 were considered [199]; a model mechanism of a single explosive eruption was described.

H WAVES

Examination of seismic records due to explosion of an atomic bomb resulted in recognition of a new type of wave called a hydrodynamic wave and tentatively labelled H [200, 201]. These H waves are surface waves and can be seen in unconsolidated sediments [202].

It is possible in certain circumstances for two Rayleigh waves to propagate over the free surface of a semi-infinite linear viscoelastic solid [203, 204]. When two such waves propagate, one is essentially of the elastic type; the other wave is prograde at the surface with the axis tilted at an angle to the free surface. The essential features of H waves have been described [202]; these waves are probably Rayleigh waves propagating in a viscoelastic medium.

OSCILLATION AND ROTATION OF THE EARTH WITH SOME MODELS

Normal [205] and toroidal [206] modes of a laterally heterogeneous body, axisymmetric free oscillations of a fluid-filled spherical shell [207], and radial oscillations of a uniform gravitating sphere with a material boundary [208] have been discussed. A method of spectral decomposition for linear operators, formulated in Dirac's bracket notation, provides excitation formulas for normal modes of infinitesimal oscillations of a nonrotating Earth [209]; the formalism has been extended to obtain corresponding formulas for a rotating Earth.

The ray method has been used [210] to study free oscillations of an incompressible, inviscid, perfectly conducting fluid of constant density contained in a rotating shell in the presence of a constant toroidal magnetic field. The excitation of oscillation of an elastic rotating Earth has been examined for the case when internal point sources and external sources of stresses vary with time according to a given law [211]. The linearized equation of motion for a slightly elliptical rotating Earth has been obtained [212]; the variational principle was derived for normal mode oscillations of Earth. A normal mode spectrum of Earth [213] as a generalized Burgers' body and a normal-mode solution for spherical Earth models [7] have been discussed. Equations for spheroidal [214-216] and radial oscillations of Earth and for a multilayered spherical Earth [218] have been discussed. The effect of modal coupling for torsional eigenvibrations of an anelastic Earth with oceanic and continental structures has been examined [219].

An iterative method for obtaining the normal modes of a laterally heterogeneous body [220] has been studied. Normal mode eigenfrequencies and eigenfunctions of an Earth with laterally variable anelasticity have been investigated [221]; the transient response of such an Earth to earthquakes has been determined. Equations of torsional oscillations of Earth have been studied [222], as has the motion of gravitating bodies subject to large initial hydrostatic stresses in a linear approximation. Analysis of the vibrational behavior of the Earth when two modes occur at nearly the same frequency and at similar amplitudes has been discussed [223]. Expressions for the kinetic, potential, and gravitational potential energies for spheroidal oscillations of a spherically symmetric, self-gravitating Earth model have been considered [224].

The origin of aperiodic signals during excitation of free oscillations in a nonelastic Earth has been studied [225]; excitation of torsional oscillations in a homogeneous Earth was considered. An Earth having both radial and lateral variations in seismic properties has been modeled [226] using finite elements; numerical algorithms are produced that yield efficient estimations of non-degenerate eigenfunctions and eigenfrequencies of this laterally nonhomogeneous spheroid. The eigenperiods of torsional oscillation of the Earth have been inverted into shear wave velocity, density, and Q structures on the constraints for the mass and moment of inertia of Earth [227]. Shear modulus and density profiles of a layered Earth have been determined [228] by torsional stress and displacement on its surface at two frequencies. The shear velocity structure from free oscillation data for an Earth model [229] with velocity discontinuities has been obtained. Variations in Q-values for two large earthquakes from damped terrestrial eigenvibrations [230] and in period and Q of free oscillations due to mode overlap [231] have been considered. An analogy in the algebraic structure between terrestrial spectra of whole Earth free oscillations belonging to different Earth models and electron energy levels of some quantum mechanical systems [232] has been discussed.

The coupling coefficient can be represented as J-square; this measure of the physical coupling of the normal modes of a vibrating system can be used for computing long-period eigenfunctions of realistic Earth models [233]. The effect of variations in the angular velocity of the Earth's rotation on the rate of change of the pulsar period [234] has been analyzed. The problem of secular variations of the Earth's rotational velocity has been reviewed [235]. The motion of the Earth's axis of inertia has been considered [236]. The inertial reference axis has an apparent wandering motion within the deformable Earth.

The Earth's polar motion contains a free component called the Chandler wobble [237]. Liouville equations have been used to study Chandler and nearly diurnal eigenfrequencies [238]. The mean wobble power excited by earthquakes is only a tiny fraction of the total power of the Chandler wobble [239]. High frequency longitudinal and transverse waves and the Chandler wobble have been discussed [240].

SEISMIC PROSPECTING

Seismic reflection prospecting is simple echo-sounding. Basic principles and methods for geophysical prospecting have been studied [241]. The history of the reflection seismograph exploration industry has been considered; and the reflection method, from its origin to the present day and into the future, has been described [242]. A brief overview of the application of wave theory in seismic exploration has been presented [243]. Seismic methods have been used to prospect for oil and natural gas deposites [244]; methods for producing a seismic pulse either in the sea or in the crust were developed to detect and record returned sounds. Seismic exploration by the reflected wave method has been explained [245], and a technique to study reflection prospecting for oil and gas has been described [246]. Some aspects of the application of blasting cord as an energy source in seismic prospecting [247] have been discussed.

The 222_{Rn} concentration in ground close to the Earth's surface provides a sensitive signal for recognizing subterranean flow of fluids. Such flows can indicate the existence of regions of enriched 222_{Rn} and hence the presence of uranium ore [248]. Measurements of the concentration of the radioactive gas radon at shallow ground depths are being used [249] in explorations for geothermal resources.

The presence of large accumulations of natural gas hydrates in cooled zones of Earth's crust has been

investigated; estimates of the gas content of the northern territories of Siberia have been reported [250]. The surface resistivity method has been used [251] to study a few exposed coal seams located in the northwestern part of the Raniganj coal field in India. Seismic survey work has been carried out, and a complex geological structure has been revealed for deposits of Neocomian age [252]. An underground structure based on simultaneous observations of earthquake ground motions under various geological conditions has been studied and the results of seismic prospectings presented [253]. Characteristics of recorded waves and peculiarities of Paleozoic deposits studied by seismic exploration have been discussed [254]. The ratio of the PP- to the SS-reflection coefficient has been used to estimate oil and gas reservoirs [255].

The three-dimensional geological problem that arises in petroleum exploration has been discussed [256]; the structure and lithology of rocks have ben mapped by imaging their acoustic reflectivity with the scalar wave equation. The use of computers in seismic reflection prospecting [257] and to identify the location of a porphyry molybdenum deposit [258] has been studied. A type of distributed charge for a seismic source in geophysical prospecting has been described [259].

EARTHQUAKE RISK

The seismic risk at a site can be defined as the probability that a given threshold level will be exceeded by a chosen variable within a time period of interest as a result of nearby seismic events [260]. Seismic risk is a combination of three factors: earthquake hazard, loss potential, and vulnerability [261].

The accuracy of stationary mathematical models of seismicity for calculating probabilities of damaging shaking has been examined [262]. A probabilistic method has been used to study seismic risks of northern Iraq [263]. Some bounds for such risks have been discussed [260]. Seismic risk maps of Egypt and its vicinity [264] and of Korea [265] have been drawn up.

The basic concepts of earthquake hazard assessment for nuclear power plant sites have been reviewed [266]. A system analysis of earthquake hazards in urban areas has been carried out [267]. The methodology currently in use in seismic risk studies has been reviewed [268]. Seismic risk including precursors [269], hazards caused by the Fukui earthquakes (28 June, 1948) [270], natural earthquakes, and related hazards [271] have been studied.

Incorporation of crustal deformation to input parameters of traditional probabilistic seismic hazard analysis has been discussed [272]. Statistical methods have been used to estimate seismic risk in a region, especially the limits of such methods for seismic engineering [273]. Seismotectonic mapping has been considered a basis for analysis of seismic hazards and earthquake forecasting [274]. Numerical experiments have been carried out to prepare tsunami hazards and to clarify some of the characteristics of earthquakes [275]. Methods for assessing the seismic safety of a lifeline system have been studied [276].

The application of earthquake seismology to reduction of hazards involves artificial control or modification of a potential earthquake source so that the energy will dissipate gradually [277]. Seismic energy can be dissipated safety [278] by piecemeal fault slippings due to injection of water between the fracture surfaces. However, earthquake-resistant construction of buildings and other structures is needed. Damage due to an earthquake can be minimized by seismic zoning and prediction of the place, time, and intensity of the earthquake [279]. Damping of earthquake intensity with distnace in connection with the problem of seismic microzoning has been studied [280].

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LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains an article about the seismic performance of low-rise light-framed wood buildings.

Dr. L.A. Soltis of Forest Products Laboratory, U.S. Department of Agriculture, Madison, Wisconsin has written a paper that reviews literature on the performance of wood structures in earthquakes, examines component and building response, and discusses current design philosophy.

SEISMIC PERFORMANCE OF LOW-RISE LIGHT-FRAMED WOOD BUILDINGS

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Abstract. This paper reviews literature on the performance of wood structures in earthquakes, examines component and building response, and discusses current design philosophy. Wood structures perform adequately when they are symmetric in plan and elevation and have adequate shear walls. Bad performance occurs when there is a lack of or nonsymmetric arrangement of racking walls.

Low-rise light-framed wood buildings have performed adequately in earthquakes provided they acted as a unit, had adequate shear walls, and were reasonably symmetric in plan and elevation. The 1971 San Fernando earthquake, however, did extensive damage to wood structures and forced a rethinking of design and construction concepts.

This paper reviews literature on the performance of wood structures in earthquakes, examines component (floors, walls, and roofs) and building response, and discusses current design philosophy. This review is limited to low-rise light-frame wood buildings with a diaphragm/shear wall lateral load-resisting system. This type of construction is used in a large number of residential, commercial, and industrial buildings. Post and beam, laminated frame and arch, and pole buildings as well as other structures such as timber bridges, retaining walls, and poles are not included.

PAST EARTHQUAKE EXPERIENCE

Prior to the 1971 San Fernando earthquake, low-rise timber structures, in general, performed well when subjected to seismic ground motion. Keenan [1] reviewed ancient structures in Asia and the Far East that had been subjected to numerous earthquakes but showed little distress. Timber structures performed well in general [2, 3] in the 1964 Alaska earthquake that measured 8.6 on the Richter scale. Failures were observed when inadequate lateral bracing occurred due either to lack of wall sheathing under the siding or to large openings, particularly near corners.

The 1971 San Fernando earthquake (6.6 Richter), however, did extensive damage to timber structures. Of the 58 deaths and 5,000 injuries, one report had two [4] and another four [5] deaths occurring in residences. No estimate of injuries occurring in residences was given; but since the earthquake occurred at approximately 6 a.m. (local time), it could be assumed that many occurred in homes. McClure [6] reported that about 20,500 single family houses were damaged, of which 730 were demolished or required major rehabilitation. He reported single family home dollar losses at between $58 and $114 million (1971 dollars); this dollar loss was larger than that of any other building category in the private sector. Housner [4] reported 6,000 residences damaged of which 450 were declared unsafe for occupancy. The discrepancy between these reports is related to geographic area included and whether data were obtained by individual survey or building permit records. Blume and Scholl [7] estimated that 30% to 60% of the low-rise (mostly wood) buildings in the exposed area were damaged; although resistant to collapse many of these buildings experienced condemnation-level damage. No specific numbers were given for commercial or industrial buildings.

The primary cause of overall residential damage [4, 6-10] in the San Fernando earthquake was inadequate lateral support. The lack of or nonsymmetrical arrangement of racking walls caused damage or collapse; most vulnerable were two-story and split-level homes with a garage on the first floor. Failures in sill plate connections and homes shifting

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off their foundations were also observed. Fuller [11] noted that the greatest deficiency of wood-frame construction was its lack of resistance to torsional racking caused by the second story being stiffer than the first (nonsymmetry). The floor diaphragm rotated in plan, lifted the rear wall from its foundation, and left only interior walls to resist further earthquake motion. Arnold [12] observed that 65% to 80% of the buildings he surveyed either were not symmetrical horizontally or did not have a uniform story plan vertically.

Two- and three-story apartment buildings, low-rise shopping centers, and schools also experienced damage due to lack of adequate bracing [10]. Large openings for parking or windows in the first story again resulted in nonsymmetry of the lateral resisting elements. Industrial buildings of tiltup concrete or masonry walls with a Berkeley roof system of preframed plywood [13] separated at the plywood-to-ledger beam connection. This resulted in loss of lateral support at the top of the wall. Although no statistics have been reported, it appears loss of lateral support was a frequent problem.

A review of photographs taken during damage surveys showed that the frame dwellings in the Alaska earthquake had simple rectangular configurations, continuous floors, and small window and door openings. These features provided a desirable symmetric box-like lateral resistive system that performed well. On the other hand, the newer San Fernando residences with split-level floor configurations, multiple roof levels, and large percentages of window and door openings were not inherent earthquake resistive systems. Their nonsymmetry made them vulnerable to torsional as well as lateral motion. A number of commercial and industrial buildings with plywood roof diaphragms were observed in the San Fernando earthquake; few were observed in the Alaska earthquake.

COMPONENT AND BUILDING RESPONSE

Floor and roof diaphragms and vertical shear (racking) walls constitute the lateral load-resisting elements of timber structures. The combination of these components is generally classified as a box system in building code nomenclature.

Floor and roof systems act as horizontal beams spanning shear walls. Whether they are rigid or flexible depends on their relative rigidity compared to that of the vertical shear walls. The diaphragm is rigid if its distortion is small compared to that of the vertical shear walls; this is the usual assumption in lumped mass dynamic analysis. The diaphragm is flexible if its distortion is comparatively large; this is the case for a timber diaphragm with concrete, masonry, or timber shear walls.

McNatt and Galligan [14] gave an overview of the types of diaphragm and framing materials available. Carney [15] presented a bibliography on wood diaphragms for literature prior to 1975; in general, he considered only statically loaded diaphragms. Peterson [16] presented a bibliography of literature through 1982 that included static and dynamically loaded wall and floor diaphragms.

Several studies [8, 17, 18] present lateral diaphragm deflection due to static loading; total deflection includes bending and shear deflection, nail slip, and chord splice slip. Foschi [19] has presented a generalized structural analysis of diaphragms that incorporates plate action and nonlinear connection behavior. Bower [20] considered diaphragms of irregular shape.

Studies [21, 22] related to vertical floor vibration in conjunction with determination of allowable live load deflection have been conducted. Fundamental frequencies of horizontal floors of 12 to 17 Hz and damping ratios (as a percent of critical damping) of 7% to 11% were found [22-25]; empirical relationships for frequency and damping to the stiffness for tongue-and-groove roof diaphragms were also presented. Rudder [26] found out-of-plane vibrations of building floors and walls to be 20 to 40 Hz when they were subjected to traffic-induced vibration.

Shear (racking) wall strength has been discussed for statically loaded walls. Little is known for dynamically loaded (in-plane) walls. Medearis [27] presented wall natural frequency as a function of roof load, shear wall weight, and stiffness. Young and Medearis [28] investigated the damping and energy absorption characteristics of plywood shear walls. A force-deflection mathematical model for diaphragms subjected to dynamic loads has been presented [29]. Two parameters, initial stiffness, and ultimate strength were used to describe the model. Adham and

Ewing [30] studied the effects of various stiffnesses of wood roof diaphragms on the response of masonry buildings. Little work has been done on combined loading; Frodin and Ross [31] tested two plywood sheathed panels subjected to racking plus uplift.

Although the seismic performance of wood, wood-based, and other sheathing materials is a function of dynamic fastener properties, little work has been done on joints subjected to cyclic and vibrational loads. The slip-damping of nailed joints was found to be an order of magnitude greater than the material damping [32]. Wilkinson [33] found joints to be considerably stiffer under vibrational load than static load. He implied that this result was related to rate and duration of load and concluded that a 33% duration of load increase in design stresses for earthquake and wind is probably conservative.

Cyclic loading does not, however, appear to influence the strength of nailed joints. Mack [34] found the ultimate strength to be unaffected by repetitive loading, and Armstrong and Schuster [35] found that load-slip behavior was dependent on the highest load applied. It has been found the effect of direction of load on slip modulus is small for plywood [36]. A study of the joint adequacy between timber rafters and ledger beams to masonry walls showed that ledgers failed when subjected to cross grain tension [37].

The response of an entire structure differs from that of its components. Natural frequencies and coefficients of critical damping have been determined in a few studies. Values of 5 to 9 Hz and 4% to 6% damping were found for one-story school buildings with plywood shear walls and glulam roof framing [38]. Medearis [39] surveyed 63 one-and-one-half and two-story residences of various ages in four states. He found little difference due to age of construction or geographic location. Natural frequencies from 4 to 18 Hz, corresponding to building heights of 40 to 10 feet (frequency is inverse to height), and average damping ratios of 5.2% were observed. Tests of a two-story residence revealed that the natural frequency was 9 Hz; average damping was 6% [40]. Average natural frequency and damping of 7 Hz and 4.6% were obtained from measurements of the dynamic response of 23 one- and two-story single family residences from surface blasts [41]. Individual shear wall natural frequency averaged 15 Hz.

Two studies have been concerned with the response of Japanese houses. Natural frequencies of a two-story house varied from 7 to 11.5 Hz [42]. Those for one-story houses were 2½ to 5 Hz; the values for two-story houses were 2 to 4 Hz [43].

DESIGN PHILOSOPHY

In comparison to other types of buildings, low-rise timber structures generally have higher natural frequencies (thus lower natural periods) and about average (5% to 10%) coefficient of critical damping. Because they are relatively rigid low-mass structures, their motion is nearly the same as that of the ground, and dynamic forces are very nearly equal to those associated with the ground accelerations applied to the structure as a rigid body; natural frequencies of higher modes of vibration are not important.

Current design is based on a static base shear equation that represents a linear approximation of a tripartite (acceleration, velocity, and displacement) response spectrum. Horizontal and vertical distributions of base shear imply that the building is vibrating laterally in one direction and that it is symmetric. If nonsymmetry and corresponding torsion are present, coupled lateral-torsional analysis is suggested [44].

Kan and Chopra [45-48] analyzed coupled torsional and translational motion by simultaneous solution of the equations of motion. They found that coupling of the two motions occurs if there is a large eccentricity between the centers of mass and rigidity in nonsymmetrical buildings or if the natural lateral frequency is close to the natural torsional frequency in symmetric buildings. They also found that the maximum base shear in a torsionally coupled system is less than in the corresponding uncoupled system; however, the dynamic torque can considerably exceed the static torque that is a product of horizontal shear times eccentricity between centers of mass and rigidity. Other studies of coupled lateral torsional motion for a one-story structure have been reported [49, 50].

A second technique [51-53] for studying the torsion problem is to treat the building as a cantilever member with open or closed cross section. The result is vertical warping displacements and stresses in addition to horizontal shear stresses. The technique has

been applied mainly to multistory buildings but is possibly also applicable to low-rise structures.

CONCLUSION

Wood structures are redundant structures, and this redundancy might explain their good performance in symmetric buildings. The number of partitions, floor and wall sheets, and sheathing fasteners allow for a redistribution of load. Failure of a single fastener or panel sheet will not precipitate a catastrophic collapse. A large number of fasteners also provides immense energy-absorbing capacity. The response of timber structures to the Alaska and San Fernando earthquakes illustrates that the horizontal and vertical diaphragms appear adequate to resist seismic-induced lateral loads when the structure is symmetric, both vertically and horizontally, and does not have large openings.

Current design practice is largely based on experience and research related to multistory buildings that are relatively symmetric, flexible structures with low natural frequencies. Low-rise wood buildings are often nonsymmetric relatively stiff structures with higher natural frequencies. Thus future research is required related to the unique problems of low-rise wood buildings.

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BOOK REVIEWS

OPTIMIZED VIBRATION TESTING AND ANALYSIS

E. Szymkowiak
Institute of Environmental Sciences, Mt. Prospect, IL
1983, 107 pages, $25.00

Vibration tests are widely used to assure the suitability of a test object for its intended use in a potentially damaging vibration environment. These tests are essential to prove in advance that an item has a high probability of survival under such vibration. Should the item fail the test, design or construction weaknesses are uncovered and can be fixed prior to usage. Costly fixes in the field can thus be minimized and, in the case of critical military hardware, lives can be saved because reliable performance of the equipment is assured on the field of battle. Items subjected to vibration tests can vary widely in size, weight complexity, and cost; the test environment can be simple or complex. Yet the procedures for conducting the tests must be safe and comform with the requirements.

This document is the text for a tutorial course on vibration testing and analysis sponsored by the Chesapeake Chapter of the IES. The author points out in the Introduction that the same basic operating procedures are used for test setup, performance, and post test data analysis regardless of the level of complexity of the test item or the nature of the environmental simulation. The objectives of the publication are clearly stated:

1. To acquaint the reader with a basic procedure to set up and perform vibration tests.

2. To provide detail on constraints which must be observed in order that tests may be performed safely and accurately.

3. To provide some insight into the major problems that can occur during vibration testing, and into the probable solutions.

There is clearly a need for training and guidance in the area of vibration testing. This publication was reviewed with two questions in mind. Does the document satisfy its stated objectives and does it stand alone as a useful guidance document?

Section II discusses the necessity for a Standard Operating Procedure (SOP) to be used by vibration test operators to set up and perform all vibration tests. An excellent flow chart for such a procedure is included in the document. The author did not include specific details on all steps in the SOP, but he did discuss a number of key steps that might involve action by an environmental simulation engineer. For example, the necessity for a complete written description of the test requirements was stressed. Alignment, survey, and checkout of the test fixture are discussed with a view to avoiding potential problems. Instrumentation and test control procedures are described, as are the necessity and means for over-test protection. Finally, procedures for test performance are given and requirements for post-test data analysis are discussed, including the advantage of quick looks at data between test phases.

Section III provides considerable detail on the constraints involved in measuring, analyzing, and interpreting data. Resolution considerations as they are affected by the selection of filter bandwidth are discussed as they relate to both response measurements and vibration test control. Record length constraints on accuracy are described, and problems of measuring relative motion or differential displacement between two parts of a structure are discussed. Interpretation of time history data is addressed, and the use of transfer functions in interpreting time synchronized data samples is discussed.

Section IV addresses problems related to the evaluation and control of the environment. The fixture survey to select control accelerometer locations, including the over-test protection accelerometer, is described in some detail; the fixture checkout to verify the test setup is briefly discussed. Averaging, particularly spatial averaging and ensemble averaging,

is discussed as it is used in the performance of a vibration test and in the reduction of resultant data. Spatial averaging is particularly important in vibration test control. Ensemble averaging involves repeated sampling, assembling the samples into an ensemble, and determining the nominal value of the elements of the ensemble. Various methods of ensemble averaging are described. The last part of Section IV contains an excellent discussion of the use of slide plates for horizontal vibration testing.

Phenomena that can cause a test to be stopped before completion are discussed in Section V in terms of operator actions designed to avoid or correct such problems. These phenomena fall into two major categories.

1. Significant and abrupt changes to the overall system transfer function.

2. Failure to properly match the parameters required by the test to be within the limitations of the overall system.

The discussion and resolution of these two categories of problems are presented in a clear and concise manner.

The last section provides a comprehensive overview of shock simulation; the use of vibration test systems is emphasized. Gunfire simulation is included. The section concludes with a description of a shock test procedure using digital control.

The publication clearly satisfies its stated objectives. It is both readable and understandable. Although there would be a definite advantage in using this document as a text with a qualified instructor present, the publication does stand on its own merits. It should be a very useful desk reference for vibration test engineers and technicians.

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PRACTICAL MACHINERY MANAGEMENT FOR PROCESS PLANTS, VOL. 2, MACHINERY FAILURE ANALYSIS AND TROUBLESHOOTING

H.P. Bloch and F.K. Geitner
Gulf Publishing Co., Houston, TX
1983, 656 pages, $69.95

This book is a must for anyone engaged in machinery analysis and troubleshooting. From the theory of failures through formal failure analysis the authors have compiled their vast experience into an easy to read and complete work. The numerous photographs of typical failures provide invaluable insight that would take years, perhaps a career, for an individual to duplicate.

Failure analysis is presented from two perspectives: the theoretical perspective that is so often neglected in the rush to repair and the practical, maintenance perspective that includes failure symptoms and methods of identification, including vibration analysis.

Theoretical aspects are covered in chapters on methods of problem solving, the statistics of reliability, formalized failure investigations, organizing for failure analysis, and sneak analysis. Sneak analysis is an especially fascinating subject that deals with unexpected paths to failure and faulty operation. Anyone who has experienced the excitement of a total power failure in a complex process plant will recognize the value of sneak analysis.

Practical aspects include a great deal of material on the mind set and disciplined thinking that must go into successful machinery troubleshooting: questions to ask, logical investigation of probable causes, and constant reminders to remain curious and accept little until everything falls into place. Numerous examples of actual failures illustrate the principles exceptionally well.

A lengthy chapter on vibration analysis (187 pages) is, for all practical purposes, a book in itself. Rotating machinery analysis is described extensively from monitoring to balancing.

Reciprocating machinery, for so long the stepchild of sophisticated analysis, is discussed; analyzer photographs show plots of typical problems. Invaluable guidance ranges from symptoms of typical problems to methods to assure accurate, representative measurements and operating limits; all information is based on the extensive experience of the authors.

Topics on lubrication, another often-ignored area, include lubrication failure, purification, conditioning, and analysis and are discussed from a practical viewpoint. Mechanical seals are another area in which detailed failure analysis can pay handsome dividends. Here again the authors have drawn on their extensive experience and provided invaluable guidance with both words and photographs.

The illustrations are invaluable and contribute immeasurably to the readability of this outstanding book. It isn't possible to list all of the subjects covered. Suffice it to say that, if you are engaged in machinery analysis, maintenance, or troubleshooting, this book should definitely be on your bookshelf during the few moments it isn't in use on your desk.

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THE FINITE ELEMENT METHOD FOR ENGINEERS

K.H. Huebner and E.A. Thornton
John Wiley & Sons, New York, NY
Second Edition, 1982, 623 pages

Seven years have elapsed since this book was first published. The most notable additions are problems after each chapter and a new chapter on heat transfer. The book is easy to read and comprehend.

The book contains 11 chapters and five appendices. A number of chapters are either the same or only slightly revised from the first edition.

Chapter 1 introduces the finite element method (FEM), its history, and applications. Chapter 2 physically interprets FEM; springs, simple elements of structural mechanics, and assembly of the parts that make up the matrix and FE are described. Chapter 3 reports on the mathematical approach using variational interpolation, including the Ritz approach, interpolation functions, piecewise approximation, and examples of FE. Chapter 4 describes a generalized mathematical approach, including the Galerkin method for a one-dimensional Poisson equation, time-dependent heat conduction, two-dimensional heat conduction, and derivation of FE equations from energy balances.

Chapter 5 covers elements and interpolation functions such as basic element shapes, types of nodes, general and natural coordinates (1, 2, and 3 dimensions), LaGrange and Hermitian polynomials, C^0 and C^1 problems, and an expanded section of curved isoparametric elements (coordinate transformation and evaluation of element matrices.

Chapter 6 deals with elasticity problems, including a general formulation for two-dimensional problems, a variational principle, a displacement interpolation function, element stiffness equations, plane stress and strain, axisymmetric stress analysis, plate bending problems, three-dimensional problems (linear and tetrahedral), and higher order elements. The structural dynamics section is an expanded version of the first edition and contains information about free and undamped vibrations, transient motion via mode superposition, and use of the Newmark method. No mention is made of Wilson θ method or Houbolt method, both of which have been successfully applied in transient analysis of structural dynamic problems.

Chapter 7 considers general field problems concerned with equilibrium, eigenvalue problems (Helmholz equation, variational principles), and propagation problems. In the concluding section previously described procedures are used to solve discretized time-dependent equations. Transient response via mode superposition and recurrence relations are discussed, as are oscillations and stability of transient response and the use of such methods as backward difference, Galerkin, Crank-Nicolson, and Euler forward difference. An interesting plot shows their relative value in stability calcuations.

Chapter 8 is concerned with lubrication expressed as finite elements. In Chapter 9 the FE is applied to

fluid dynamic problems. Recent advances in formulating and solving problems in inviscid compressible flow and viscous incompressible flow are described. New concepts include the penalty function and upwind weighing functions.

Chapter 10 on heat transfer problems has been expanded from the previous edition. Topics include conduction in FE formulation, element equations, linear and nonlinear steady-state and transient problems, conduction containing surface radiation (steady-state and transient radiation), convection-diffusion equations for both one and two dimensions, free and forced convection, and solution techniques.

The last chapter contains a sample computer code, information on preparation of input data and output data, and a FORTRAN listing. A simple heat conduction problem and heat transfer in built up sections are provided. The concluding sections include a short discussion of automatic mesh generation, numerical integration formulas, and a new section on solving linear and nonlinear matrix equations.

The appendices include sections on matrices, variational calculus, basic equations from linear elasticity theory, fluid mechanics, and basic equations of heat transfer.

The authors present an up-to-date version of FE. The reviewer feels that sections on component mode method, consistent mass in structural dynamics should have been included. The penalty function method should be expanded and mesh layout for stress concentration of circular holes in plates and shells should also be included.

H. Saunders
1 Arcadian Drive
Scotia, New York 12302

THEORY OF ELASTIC SHELLS

M. Dikmen
Pitman Publishing, Inc., Marshfield, MA
1982, 364 pages, $65.95

As stated by the author, this book "covers a range of topics that have not been brought together in a single normograph on shell theory . . . I have chosen to concentrate on foundations, methods and essential facts." This book requires a fundamental knowledge of strength of materials (elementary and advanced) and dynamics.

The first of 14 chapters introduces shell theory. Topics in Chapter 2 include differential geometry on and near a reference surface and an explanation of and applications of tensor theory. Chapter 3 has to do with kinematics of the shell, including base vectors and compatibility conditions. Chapter 4 is concerned with the general balance equation and includes equations of motion and conservation of energy and a method for expanding stress components. Chapter 5 treats constitutive relations for elastic shells; three-dimensional hyperelastic bodies; and general constitutive equations for hyperelastic bodies and hyperelastic shells. Chapter 6 has to do with kinematics: approximations, equations of motion, and boundary conditions.

Chapter 7 describes various aspects of membrane theory including linear theory of statics of elastic membranes, differential equations of deformation in linear theory, bending tensors, explicit forms of linear constitutive equations, the membrane equation in Cartesian coordinates, Caughy-Riemann equations, boundary conditions, and nonlinear theory of the first order. Chapter 8 focuses on bending theories, linearized equations of motion, constitutive equations of linear bending theory, Trefftz's method, and the well known Love-Kirchoff hypothesis. The concluding sections cover direct integration of stresses, mixed tensor formulation of linear theory, boundary conditions, and nonlinear bending theories.

Chapter 9 is concerned with the theory of shells. Shells are considered to be bounded regions of some deformable two-dimensional manifold and include polyhedra and isometric surfaces. Openings and slits that can prevent the shell from maintaining its form are described by rigidity theories and rigid point Cosserat and Cosserat surfaces. The chapter concludes with a general discussion of constitutive equations. Chapter 10 explains classical solutions to equilibrium problems, solutions for linear problems, and constitutive equations in general as well as those applied to shallow shells.

The next chapter contains an excellent discussion of the stability of shells, including branching theory and

bifurcation applied to deep and shallow shells, an asymptotic method for determining upper critical loads and post buckling behavior, and an initial value approach to study load-deformation of shells, imperfection sensitivity, and problems of dynamic stability.

Chapter 12 treats various error estimates. Included are estimates in the form of residuals, pointwise bounds in boundary value problems, approximations by linear variational theories, and global estimates for comparing shell theories. The final section describes the method of small parameters, three-dimensional edge effects, and bounds for approximate solutions.

The next chapter treats the dynamics of shells. Topics include linear differential equations, free vibration and asymptotic study of free vibration, frequency equation and bending edge effects, modal lines, spectral theorems, density of eigenfrequencies, wave propagation, acoustics, dynamics of loaded shells, and thickness effects. Concluding sections are concerned with nonlinear dynamic problems of shells with emphasis on complete shells, nonlinear wave processes, and an analytical perturbation method for nonlinear free vibrations. In the reviewer's opinion this chapter is incomplete. No mention is made of cones, spherical shells, or toroidal sections, all of which are common in shell construction.

The concluding chapter covers statistical problems of shell theory. This fairly new subject is not usually included in books on shell theory. Topics are probability theory, linear stochastic theory, problems of random perturbation, probability distribution for critical loads, probability of failure, Fokker-Planck equations with applications to cylindrical panels, and use of Pontriagin's equations. The last equations are used in reliability theory as applied to the stability of a system. The reviewer believes this chapter is too short and should have considered statistical effects applied to dynamic buckling of shells, statistical theory applied to thermal stresses, and applications of stochastic theory applied to shallow cylindrical panels.

The reviewer feels that an introduction to finite element and finite difference methods applied to shells should have been included. Such information would have enhanced the chapter on error estimates. In addition, approximation methods -- e.g., Rayleigh-Ritz and Galerkin -- should have been included. Although the book is theoretically adequate, the author should have incorporated examples of other types of shells; i.e., cones, spherical, and toroidal shells.

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SHORT COURSES

DECEMBER

FIELD INSTRUMENTATION AND DIAGNOSTICS
Dates: December 3-6, 1984
Place: Houston, Texas
Objective: To provide a balanced introduction to diagnostic instrumentation and its applications for evaluating rotating machinery behavior. The seminar also covers fundamental rotating machinery behavior and some of the more common machinery malfunctions. It includes a lab session with workshops on data acquisition instrumentation, balancing, oil whirl/whip and rubs, and monitor system calibration.

Contact: Bob Grissom, Customer Training Department, Bently Nevada Corporation, P.O. Box 157, Minden, NV 89423 - (702) 782-9315.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION
Dates: December 3-7, 1984
Place: Huntsville, Alabama
Dates: February 4-8, 1985
Place: Santa Barbara, California
Dates: March 11-13, 1985
Place: Washington, D.C.
Dates: May 6-10, 1985
Place: Boston, Massachusetts
Dates: June 3-7, 1985
Place: Santa Barbara, California
Dates: August 26-30, 1985
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

JANUARY

RELIABILITY METHODS IN MECHANICAL AND STRUCTURAL DESIGN
Dates: January 7-11, 1985
Place: Tucson, Arizona
Objective: The objective of this short course and workshop is to review the elements of probability and statistics and the recent theoretical and practical developments in the application of probability theory and statistics to engineering design. Special emphasis will be given to fatigue and fracture reliability.

Contact: Special Professional Education, Harvill Bldg., Box 9, College of Engineering, University of Arizona, Tucson, AZ 85721 - (602) 621-3054.

FEBRUARY

VIBRATIONS OF RECIPROCATING MACHINERY
Dates: February 19-22, 1985
Place: San Antonio, Texas
Objective: This course on vibrations of reciprocating machinery includes piping and foundations. Equipment that will be addressed includes reciprocating compressors and pumps as well as engines of all types. Engineering problems will be discussed from the point of view of computation and measurement. Basic pulsation theory -- including pulsations in reciprocating compressors and piping systems -- will be described. Acoustic resonance phenomena and digital acoustic simulation in piping will be reviewed. Calculations of piping vibration and stress will be illustrated with examples and case histories. Torsional vibrations of systems containing engines and pumps, compressors, and generators, including gearboxes and fluid drives, will be covered. Factors that should be considered during the design and analysis of foundations for engines and compressors will be discussed. Practical aspects of the vibrations of reciprocating machinery will be emphasized. Case

histories and examples will be presented to illustrate techniques.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MACHINERY VIBRATION ANALYSIS

Dates: February 19-22, 1985
Place: San Antonio, Texas
Dates: August 13-16, 1985
Place: Nashville, Tennessee
Dates: October 29 - November 1, 1985
Place: Oak Brook, Illinois

Objective: This course emphasizes the role of vibrations in mechanical equipment, instrumentation for vibration measurement, techniques for vibration analysis and control, and vibration correction and criteria. Examples and case histories from actual vibration problems in the petroleum, process, chemical, power, paper, and pharmaceutical industries are used to illustrate techniques. Participants have the opportunity to become familiar with these techniques during the workshops. Lecture topics include: spectrum, time domain, modal, and orbital analysis; determination of natural frequency, resonance, and critical speed; vibration analysis of specific mechanical components, equipment, and equipment trains; identification of machine forces and frequencies; basic rotor dynamics including fluid-film bearing characteristics, instabilities, and response to mass unbalance; vibration correction including balancing; vibration control including isolation and damping of installed equipment; selection and use of instrumentation; equipment evaluation techniques; shop testing; and plant predictive and preventive maintenance. This course will be of interest to plant engineers and technicians who must identify and correct faults in machinery.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MARCH

PENETRATION MECHANICS

Dates: March 18-22, 1985
Place: San Antonio, Texas

Objective: This course presents the fundamental principles of penetration mechanics and their application to various solution techniques in different impact regimes. Analytical, numerical, and experimental approaches to penetration and perforation problems will be covered. Major topic headings of the course are: fundamental relationships, material considerations, penetration of semi-infinite targets, perforation of thin targets, penetration/perforation of thick targets, hydrocode solution techniques, experimental techniques. Discussions will include such topics as fragment or projectile breakup, obliquity, yaw, shape effects, and richochet. Shock propagation, failure mechanisms and modeling, constitutive relations, and equation-of-state will be presented in the context of penetration mechanics. Developed fundamental relationships will be applied in the following areas: hypervelocity impact, long rod penetration; spaced and composite armors, explosive initiation, hydrodynamic ram, fragment containment, earth penetration, crater/hole size, spallation, shaped charge penetration.

Contact: Ms. Deborah J. Stowitts, Southwest Research Institute, 6220 Culebra Road, San Antonio, TX 78284 - (512) 684-5111, Ext. 2046.

VIBRATION CONTROL

Dates: March 25-29, 1985
Place: Manassas, Virginia
Dates: June 3-7, 1985
Place: San Diego, California

Objective: This vibration control course will include all aspects of vibration control except alignment and balancing. (These topics are covered in separate Institute courses.) Specific topics include active and passive isolation, damping, tuning, reduction of excitation, dynamic absorbers, and auxiliary mass dampers. The general features of commercially available isolation and damping hardware will be summarized. Application of the finite element method to predicting the response of structures will be presented; such predictions are used to minimize structural vibrations during the engineering design process. Lumped mass-spring-damper modeling will be used to describe the translational vibration behavior of packages and machines. Measurement and analysis of vibration responses of machines and structures are included in the course. The course emphasizes the practical aspects of vibration control. Appropriate

case histories will be presented for both isolation and damping.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MODAL TESTING

Dates: March 25-29, 1985
Place: Manassas, Virginia
Dates: June 3-7, 1985
Place: San Diego, California
Objective: Vibration testing and analysis associated with machines and structures will be discussed in detail. Practical examples will be given to illustrate important concepts. Theory and test philosophy of modal techniques, methods for mobility measurements, methods for analyzing mobility data, mathematical modeling from mobility data, and applications of modal test results will be presented.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

MAY

ROTOR DYNAMICS

Dates: May 6-10, 1985
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

INTERNATIONAL MODAL ANALYSIS CONFERENCE
January 28-31, 1985
Orlando, Florida

The Third International Modal Analysis Conference will be held at the Marriott Inn, International Drive, Orlando, Florida on January 28-31, 1985. IMAC is the only conference devoted exclusively to the technology of modal analysis of vibrating structures. More than 200 technical papers from 23 countries will be presented, dealing with both analytical and experimental methods in modal analysis. A comprehensive exhibit of modern modal analysis equipment and peripherals will be shown by leading firms. The IMAC Conference is sponsored by Union College with the cooperation of the University of Cincinnati.

For further information contact: Ms. Rae D'Amelio, Graduate and Continuing Studies, Union College, Wells House, 1 Union Ave., Schenectady, NY 12308 - (518) 370-6288.

INTERNATIONAL SYMPOSIUM ON AEROELASTICITY AND STRUCTURAL DYNAMICS
April 1-3, 1985
Aachen, Germany

The Second International Symposium on Aeroelasticity and Structural Dynamics will be held at the Technical University of Aachen, Germany, from April 1-3, 1985.

The symposium is intended to give aerospace engineers a comprehensive survey of the current status of research and development work in the fields of aeroelasticity and structural dynamics.

The organizing committee agreed to extend the scope of this symposium to include problems in the field of spacecraft engineering in addition to the aircraft-related topics dealt with at the first symposium in Nuremberg. This was considered a meaningful extension due to the fact that the methodologies applied are largely the same, regardless whether aircraft or spacecraft problems are concerned.

In addition to the formal delivery of papers, the objective of this symposium is to create an atmosphere conducive to discussion and the exchange of viewpoints and experience.

The final program of the symposium will be available in January 1985, together with application forms for attendance at the symposium.

English will be the official language at the symposium. There will be no simultaneous translation during the sessions.

An official reception and symposium banquet will be included. If sufficient interest is expressed, a social program will be arranged.

For further information contact: Symposium Organizing Secretariate, Deutsche Gesellschaft fur Luft- und Raumfahrt, Godesberger Allee 70, D-5300 Bonn 2, W. Germany.

ABSTRACTS FROM THE CURRENT LITERATURE

ABSTRACT CONTENTS

AVAILABILITY OF PUBLICATIONS ABSTRACTED

None of the publications are available at SVIC or at the Vibration Institute, except those generated by either organization.

Periodical articles, society papers, and papers presented at conferences may be obtained at the Engineering Societies Library, 345 East 47th Street, New York, NY 10017; or Library of Congress, Washington, D.C., when not available in local or company libraries.

Government reports may be purchased from National Technical Information Service, Springfield, VA 22161. They are identified at the end of bibliographic citation by an NTIS order number with prefixes such as AD, N, NTIS, PB, DE, NUREG, DOE, and ERATL.

Ph.D. dissertations are identified by a DA order number and are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48108.

U.S. patents and patent applications may be ordered by patent or patent application number from Commissioner of Patents, Washington, D.C. 20231.

Chinese publications, identified by a CSTA order number, are available in Chinese or English translation from International Information Service, Ltd., P.O. Box 24683, ABD Post Office, Hong Kong.

When ordering, the pertinent order number should always be included, not the DIGEST abstract number.

A List of Periodicals Scanned is published in issues, 1, 6, and 12.

MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2463, 2599, 2601)

84-2370

Seismic Analysis of a Rotor-Bearing System

V. Srinivasan and A.H. Soni

Oklahoma State Univ., Stillwater, OK 74078, Earthquake Engrg. Struc. Dynam., 12 (3), pp 287-311 (May/June 1984) 17 figs, 2 tables, 27 refs

Key Words: *Rotors, Seismic analysis, Time-domain method*

The seismic analysis of a rotor-bearing system is presented in the time domain. The governing equations of motion for the rotor are derived including the effects of rotatory inertia, shear deformation, gyroscopic effects, axial force, axial torque, stiffness and damping provided by the lubricants in the bearings, base translation and base rotation. A simple and efficient finite rotor element based on a Galerkin formulation is proposed to model the rotor. The effects of disks and flywheels mounted on the rotor are also included in the analysis. An example problem for a rotor-bearing system is solved.

84-2371

Self-Induced Asynchronous Instability in a Partially Filled Rotating Centrifuge on an Elastic Support System

C.-H.A. Cheng

Ph.D. Thesis, Univ. of Minnesota, 287 pp (1983) DA8404136

Key Words: Rotors, Fluid-filled containers, Elastic supports, Whirling

Results of an experimental investigation of the asynchronous whirling motion of a partially filled rotating centrifuge on an elastic support system are presented. An experimental facility was designed for measurements of the amplitude of whirl. The amplitude data were used to deduce the stability boundaries of the asynchronous whirl. The effects of various parameters on the stability boundaries were studied systematically. The parameters include the fill ratio, mass ratio, damping of the elastic support system, and the Reynolds number. The experimental results are consistent with the theoretical predictions based on a linear analysis.

84-2372

A Flexible Rotor under External Magnetic Excitation

F.P. Lepore and V. Steffen, Jr.

Federal Univ. of Uberlandia - 38400 Uberlandia, M.G.-Brazil, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 776-781, 11 figs, 3 refs

Key Words: Rotors, Flexible rotors, Magnetically induced vibrations, Vibration control

A mathematical model of a rigid disc mounted on a flexible shaft supported by ball bearings is presented. Two external nonlinear magnetic oscillating forces are applied to the disc to minimize the vibration level of the rotor when running *at critical speeds or at operating speeds.*

84-2373

Soil Influence on Unbalance Response and Stability of a Simple Rotor-Foundation System

R. Gasch, J. Maurer, and W. Sarfeld

Technische Universitat Berlin, D-1000 Berlin, W. Germany, J. Sound Vib., 93 (4), pp 549-566 (Apr 22, 1984) 16 figs, 2 tables, 7 refs

Key Words: Rotors, Interaction: rotor-foundation, Elastic half-space, Damping effects

The equations of motion are set up for a simple rotor (Jeffcott or Laval rotor) on a rigid foundation mass resting on an elastic half space (soil). The unbalance response and the stability limit against self-excited vibrations caused by the internal damping of the rotating shaft are calculated. The numerical results presented as response diagrams and stability graphs show that the damping effect of the soil on the system, due to radiation of energy, may have a very positive influence on the smooth running of the rotors.

84-2374

Avoiding Destructive Shaft Vibrations

J.H. Ferguson and J.A. Stocco

Bendix, Fluid Power Div., Allied Corp., Utica, NY, Mach. Des., 56 (13), pp 96-98 (June 7, 1984) 3 figs

Key Words: Shafts, Vibration control, Design techniques

Measures for the prevention of destructive shaft vibrations are described which take the components of the entire rotating system into consideration in the design stage.

84-2375

The Design of Low-Noise Automotive Cooling Systems with Axial-Flow Fans (Geräuschoptimierung von Fahrzeugkühlsystemen mit Axiallüfter und Saugseitig angeordnetem Wärmetauscher)

R. Von Hofe and G.E. Thien

Rembrandtgasse 2, A-8010 Graz, Automobiltech. Z., 86 (4), pp 161, 162, 165-169 (Apr 1984) 12 figs, 1 table, 10 refs

(In German)

Key Words: Fans, Automobile engines, Noise reduction, Design techniques

The reduction of the noise radiated by a vehicle requires treatment of all dominant sources including the cooling system of the engine. Noise emitted by the cooling fan is influenced by various components of the cooling system and by those parts of the vehicle representing obstacles in the air flow. This paper is based on research work that covered all relevant parameters -- type of fan, position of fan, shape and position of annular cowl, design of the shroud, and size and position of the radiator core. A design method is demonstrated for achieving an optimum noise level with a given installation envelope and geometrical restrictions for a cooling system.

84-2376

Transverse Plunger Motion in the Annular Gap Between the Plunger and Barrel of a Diesel Injection Pump (Kolbenquerverlagerung im Dichtspalt eines Einspritzpumpenelements)

L. Röhl and K. Prescher

Institute f. Motorenbau Prof. Huber e.V. Eggenfeldener Str. 104, D-8000 Munchen 81, W. Germany, MTZ Motortech. Z., 45 (1), pp 27-32 (Jan 1984) 12 figs, 3 refs

(In German)

Key Words: Pumps, Diesel engines, Computer programs, Periodic response

As part of a research project mathematical models were developed to determine the pressure distribution, deformation of structural parts and leakage of fuel in the annular gap between the plunger and barrel of a diesel injection pump in consideration of transverse plunger motion. The aims of this investigation are to establish a computer program to estimate these quantities and to discover the physical causes of the malfunctions sometimes observed during operation of injection pumps.

84-2377

Characteristics of Fluidborne Noise Generated by Fluid Power Pump (2nd Report, Pressure Pulsation in Balanced Vane Pump)

E. Kojima, M. Shinada, and T. Yoshino

Kanagawa Univ., 3-27-1, Rokkakubashi, Kanagawa-ku, Yokohama, Japan, Bull. JSME, 27 (225), pp 475-482 (Mar 1984) 13 figs, 2 tables, 4 refs

Key Words: Pumps, Vanes, Noise generation

A discharge pulsating pressure (fluidborne noise) generated by a balanced vane pump includes three types of pressure oscillations; namely, the pressure ripple with a fundamental component at vane frequency together with harmonics, the low-frequency pressure oscillation with a fundamental component at rotational frequency of the rotor together with harmonics, and the transient high-frequency pressure oscillation occurring with a period of vane frequency. The experimental values of the pressure ripple can be well explained up to the 8th harmonic by calculated values based on present mathematical models for flow ripple considering fluid compressibility and pump source impedance.

METAL WORKING AND FORMING

84-2378

Dynamic Behaviour of Cutting Machine Tools (Dynamisches Verhalten spanender Werkzeugmaschinen)

E. Rogel

Institut f. Werkzeugmaschinen und Fertigungstechnik der TU Berlin, VDI-Z, 126 (7), pp M3-M8 (Apr 1984) 14 figs, 13 refs

(In German)

Key Words: Machine tools, Cutting

Causes for the deformation of machine tools, especially the effect of cutting knives, are explained and means for con-

trolling the deformation are discussed. In addition, methods for the determination of dynamic characteristics of individual machines or machine groups are surveyed.

suspension bridges and the determination of their response under railway loading.

STRUCTURAL SYSTEMS

BRIDGES

84-2379

Stress Cycles for Fatigue Design of Steel Bridges

C.G. Schilling

3535 Mayer Dr., Murrysville, PA 15668, ASCE J. Struc. Engrg., 110 (6), pp 1222-1234 (June 1984) 6 figs, 2 tables, 24 refs

Key Words: Bridges, Steel, Fatigue life

Analytical methods are used to develop design values for the number of stress cycles caused by the passage of a truck across various types of spans of steel highway bridges. Vibration stresses and close truck spacings are shown to have little effect on such design values under normal conditions.

84-2380

The Role of Time Integration in Suspension Bridge Dynamics

F. Brancaleoni and D.M. Brotton

Istituto di Scienza delle Costruzioni dell'Universita di Roma, Rome, Italy, Intl. J. Numer. Methods Engrg., 20 (4), pp 715-732 (Apr 1984) 12 figs, 38 refs

Key Words: Bridges, Suspension bridges, Aerodynamic loads, Moving loads

After a brief discussion of the relative advantages of the modal and evolutional approaches to the solution of suspension bridge dynamic problems, the latter was studied in more detail and it was concluded that both explicit and implicit procedures should be included in a general package for the dynamic analysis of cable structures. Two explicit integration algorithms were selected and analyzed with respect to their stability, accuracy and error propagation behavior. The examples show the ability of the algorithms to carry out satisfactorily the aerodynamic stability analysis of suspension bridges and the determination of their response under railway loading.

BUILDINGS

84-2381

Wind Loads on Low-Rise Buildings: A Review of the State of the Art

T. Stathopoulos

Centre for Building Studies, Concordia Univ., Montreal, Quebec, Canada H3G 1M8, Engrg. Struc., 6 (2), pp 119-135 (Apr 1984) 18 figs, 3 tables, 82 refs

Key Words: Buildings, Wind-induced excitation, Reviews

This paper refers to the most recent research on wind loads on low-rise buildings. Novel measurement techniques and methodologies are reviewed, and selected experimental results from various studies are presented. Particular emphasis is given to works aimed at the formulation of codified data; i.e., results appropriate for incorporation into design standards and codes of practice.

84-2382

Model for Predicting the Acrosswind Response of Buildings

A. Kareem

Univ. of Houston, Houston, TX, Engrg. Struc., 6 (2), pp 136-141 (Apr 1984) 9 figs, 16 refs

Key Words: Buildings, Wind-induced excitation

A model is presented for predicting the acrosswind response of isolated square cross-section buildings to typical atmospheric boundary layers over different terrains. Closed-form expressions for the auto- and co-spectra of the acrosswind force fluctuations are formulated, based on wind tunnel measurements. A statistical integration scheme is used to develop a mode-generalized acrosswind spectrum for any desired approach flow condition; i.e., open country, suburban and urban. A simplified expression based on random vibration analysis is used to compute the model response.

84-2383

Control of Coupled Lateral-Torsional Motion of Buildings under Environmental Loads

B. Samali

Ph.D. Thesis, The George Washington Univ., 253 pp (1984)
DA8405298

Key Words: Buildings, Active damping, Ground motion, Seismic excitation, Wind-induced excitation

An investigation is made of the possible application of active control systems to tall buildings when excited by random earthquake ground motion or random wind turbulence. The effectiveness of the active mass damper and the active tendon system as measured by the reduction of the coupled lateral-torsional motions of tall buildings is studied. Non-optimal closed-loop control law is applied which waives the requirement for on-line computations for regulating active control forces. Although the control law suggested here is not optimal, from the analyses conducted, significant reductions in structural responses are observed when the control parameters are designed appropriately.

84-2384

Design for Seismic Torsional Forces

J.L. Humar

Dept. of Civil Engrg., Carleton Univ., Ottawa, Ontario, Canada K1S 5B6, Can. J. Civil Engrg., 11 (2), pp 150-163 (June 1984) 12 figs, 7 refs

Key Words: Buildings, Seismic response, Torsional response

An analytical study of the responses of a single story and a multistory building model to a combined translational and rotational ground motion is presented. The models, which are assumed to be elastic, are eccentric about one plan direction but are symmetric about the perpendicular direction. The ground excitations are represented by idealized spectra. A critical evaluation is made of the torsion provisions of the National Building Code of Canada.

84-2385

Time-Dependent Variance and Covariance of Responses of Structures to Non-Stationary Random Excitations

C.W.S. To

Univ. of Calgary, Calgary, Alberta, Canada T2N 1N4, J. Sound Vib., 93 (1), pp 135-156 (Mar 8, 1984) 4 figs, 2 tables, 17 refs

Key Words: Random response, Buildings, Structural response

Techniques for the analysis of nonstationary random responses of linear structures, discretized by the finite element method so that they can be analyzed as multi-degree of freedom systems, subjected to nonstationary random excitation are developed. The nonstationary random excitation is represented as a product of an exponentially decaying function and a white noise process, and a modulating function in the form of an exponential envelope and a white noise process. Closed form expressions for the time-dependent variance and covariance of responses of structures are presented. Application of these expressions is made for the analysis of nonstationary random responses of a physical model of a class of mast antenna structures subjected to base excitation.

84-2386

Assessment of Seismic Survivability

R.E. McClellan

Energy and Resources Div., Aerospace Corp., El Segundo, CA, Shock Vib. Bull., No. 54, Pt. 2, pp 193-202 (June 1984) 5 figs, 6 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Buildings, Multistory buildings, Seismic design, Earthquake damage, Vulnerability

Rigorous assessment of seismic survivability, although not required by existing codes for civil-architectural structures, is possible by rational analytical methods which enable derivation of a structure's time history of distortion when it is subjected to base motion of given displacement time history. The methods, which account for real non-linear material and structure properties, as well as the effects of previous earthquakes on structure ductility, are demonstrated in application to high-rise buildings, and inferences regarding the effect of some commonly used structural details on seismic survivability of high-rise buildings are discussed.

TOWERS

(Also see Nos. 2407, 2504)

84-2387

Hydrodynamic Coefficients of a Mooring Tower

S. Chakrabarti and D. Cotter

Marine Research, Chicago Bridge and Iron, Inc., Plainfield, IL 60605, J. Energy Resources Tech.,

Trans. ASME, 106 (2), pp 183-190 (June 1984) 16 figs, 6 refs

Key Words: Towers, Off-shore structures, Wave forces

Wave tank tests have been performed on an articulated tower in order to determine the hydrodynamic coefficients associated with the tower. The tower was a uniform diameter rigid cylinder and incorporated a localized load sensing device. It was tested in three different phases: fixed in regular waves, mechanically oscillated in still water, and free to move in the direction of regular waves. Thus, different forms of the Morison equation could be compared. The forces on the small load sensing segment were measured and the coefficients were correlated with local values of KC and Re.

FOUNDATIONS

84-2388

Simple Radiation Damping Model for Piles and Footings

G. Gazetas and R. Dobry

Rensselaer Polytechnic Inst., Troy, NY 12181, ASCE J. Engrg. Mech., 110 (6), pp 937-956 (June 1984) 10 figs, 37 refs

Key Words: Interaction: soil-structure, Viscous damping, Pile structures, Footings

A simple model is developed to obtain radiation damping coefficients of soil-foundation systems for both plane-strain and axisymmetric loading conditions. Despite the simplifying assumptions made, the obtained closed-form results are in very good accord with available rigorous solutions for strip footings, circular footings and piles, resting on or embedded in a homogeneous space and subjected to vertical and horizontal vibration.

84-2389

Dynamic-Stiffness Matrix of Soil by the Boundary-Element Method: Conceptual Aspects

J.P. Wolf and G.R. Darbre

Electrowatt Engrg. Services Ltd., 8022 Zurich, Switzerland, Earthquake Engrg. Struc. Dynam., 12 (3), pp 385-400 (May/June 1984) 11 figs, 10 refs

Key Words: Soils, Interaction: soil-structure, Dynamic stiffness, Boundary element technique

Starting from a weighted-residual formulation, the various boundary-element methods; i.e., the weighted-residual technique, the indirect boundary-element method and the direct boundary-element method, are systematically developed for the calculation of the dynamic-stiffness matrix of an embedded foundation. In all three methods, loads whose analytical response in the unbounded domain can be determined are introduced acting on the continuous soil towards the region to be excavated. In the weighted-residual technique and in the indirect boundary-element method, a weighting function is used; in the latter case, it is selected as the Green's function for the surface traction. In the direct boundary-element method, the surface traction along the structure-soil interface is interpolated. The same type of boundary matrices which have a clear physical interpretation are identified in the three formulations, each of which is illustrated with a simple static example.

84-2390

Dynamic-Stiffness Matrix of Soil by the Boundary-Element Method: Embedded Foundation

J.P. Wolf and G.R. Darbre

Electrowatt Engrg. Services Ltd., 8022 Zurich, Switzerland, Earthquake Engrg. Struc. Dynam., 12 (3), pp 401-416 (May/June 1984) 13 figs, 9 tables, 13 refs

Key Words: Soils, Interaction: soil-structure, Dynamic stiffness, Boundary element technique, Green function

Green's influence functions are derived for a linearly distributed load acting on part of a layered elastic halfplane on a line which is inclined to the horizontal. Using these Green's functions as fundamental solutions in the boundary-element method, the dynamic-stiffness matrices of the unbounded soil with excavation, of the excavated part and of the free field are calculated.

84-2391

Seismic Design Technology for Breeder Reactor Structures. Volume 2. Special Topics in Soil/Structure Interaction Analyses

D.P. Reddy

Agbabian Associates, El Segundo, CA, Rept. No. DOE/SF/01011-T25-V.2, 134 pp (Apr 1983) DE84004809

Key Words: Seismic analysis, Seismic design, Interaction: soil-structure

This volume is divided into six chapters: definition of seismic input ground motion, review of state-of-the-art procedures,

analysis guidelines, rock/structure interaction analysis example, comparison of two- and three-dimensional analyses, and comparison of analyses using FLUSH and TRI/SAC Codes.

UNDERGROUND STRUCTURES

84-2392

Dynamic Response of Concrete and Concrete Structures

L.E. Malvern and C.A. Ross
Dept. of Engrg. Sciences, Univ. of Florida, Gainesville, FL, Rept. No. AFOSR-TR-84-0165, 50 pp (Jan 26, 1984)
AD-A139 294

Key Words: Concretes, Reinforced concrete, Underground structures, Impulse response, Explosion effects

This report describes the first-year activity of a three-year research program whose objectives are to develop a loading function for close proximity explosions, determine dynamic strength properties for selected types of concrete, incorporate the strength properties so determined into a localized failure criterion for reinforced concrete, use a structural analysis elastic/plastic finite element computer program to determine localized response for a concrete/steel finite element mesh, and combine all of these into a simple structural analysis program to determine response of underground structures to localized impulsive loads.

84-2393

Finite Element Versus Simplified Methods in the Seismic Analysis of Underground Structures

A. Gomez-Masso and I. Attalla
Berliner Str. 290, 6050 Offenbach, W. Germany, Earthquake Engrg. Struc. Dynam., 12 (3), pp 347-367 (May/June 1984) 22 figs, 5 tables, 11 refs

Key Words: Tunnels, Underground structures, Seismic analysis, Finite element technique, Interaction: soil-structure

Seismic analysis of buried tunnels is considered. A comparison of results is carried out between a detailed finite element analysis and several simplified models for hand calculation.,

84-2394

Evaluation of Deformation of Tunnel Structure Due to Izu-Oshima-Kinkai Earthquake of 1978

H. Kawakami
Dept. of Construction Engrg., Saitama Univ., 255 Shimo-Okubo, Urawa City, Saitama, 338 Japan, Earthquake Engrg. Struc. Dynam., 12 (3), pp 369-383 (May/June 1984) 19 figs, 11 refs

Key Words: Tunnels, Underground structures, Seismic design, Earthquake damage

Due to an earthquake in 1978, a single-track railway tunnel in Japan was severely damaged. This damage was mainly caused by the main fault and a subsidiary fault which is estimated to have traversed the tunnel. The objective of this paper is to evaluate the performance of available mathematical models of earthquake wave propagation by taking advantage of the actual damage data of this tunnel and to contribute to the earthquake-resistant design procedure of the tunnel in the source region by estimating its deformation using the fault mechanical model.

HARBORS AND DAMS

84-2395

Waves in Open Channels

J. Shi and Chia-Shun Yih
Tech. Univ. of Water Resources, Nanking, China, ASCE J. Engrg. Mech., 110 (6), pp 847-870 (June 1984) 11 figs, 4 tables, 5 refs

Key Words: Channels (waterways), Wave forces

Gravity waves in trapezoidal channels and channels with curved bottoms, including sloshing, longitudinal, and combined modes, are treated. Analytical-numerical solutions are given for the wave frequency and the velocity potential for waves in trapezoidal channels, and analytical solutions based on the shallow-water theory are obtained for waves in curved channels.

84-2396

Vibration Modes and Frequencies of Cross Section of an Aquaduct

V. Jakūbauskas and G. Jakūbauskienė
Kaunas Polytechnic Institute, Kaunas, Lithuanian SSR, Problems in Theor. and Appl. Mechanics, 26th

Proc. in Mechanics, Vilnius Civ. Engrg. Inst., Lithuanian SSR, 1984, pp 117-125, 4 figs, 2 refs

Key Words: Dams, Mode shapes, Natural frequencies

The paper presents the solution of the hydroelasticity problem of the cross section of an aquaduct partially filled with water by the method of electoanalog. The results show that the modes of vibration in air and water differ only slightly but the difference in their frequency amounts to 40%.

CONSTRUCTION EQUIPMENT

84-2397

Guidelines for Controlling Drill String Vibrations

D.W. Dareing

Norton Christensen, Inc., Houston, TX 77073, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 272-277 (June 1984) 6 figs, 4 tables, 11 refs

Key Words: *Drills, Vibration control*

Bottom-hole assemblies control the vibration response of drill strings because they are much heavier and stiffer than drill pipe. The length of bottom-hole assemblies is also a factor and the present practice of determining drill collar length often leads to natural tuning with drill bit displacement frequencies. As a result, bottom-hole assemblies are unintentionally designed to vibrate. This paper explains the causes of severe drill string vibrations and gives guidelines for controlling them.

84-2398

Drill Collar Length is a Major Factor in Vibration Control

D.W. Dareing

Norton Christensen Drilling Products, Houston, TX 77073, J. Pet. Tech., 36 (4), pp 637-644 (Apr 1984) 10 figs, 3 tables, 6 refs

Key Words: Drills Vibration control

Drill collar length directly affects the overall vibration response of drillstrings. Drill collar length is partly responsible for severe vibrations in hard rock drilling but can also be the solution to vibration control. This paper gives a new interpretation to the cause and control of drillstring vibrations and presents the results in terms of formulas that can be directly applied by the drilling engineer.

84-2399

Computation and Measurement of Vibrations Occurring in Bucket Wheel Excavators (Schwingungen von Schaufelradbaggern Berechnung und Messungen)

D. Feder and G. Hirsch

KRUPP Industrietechnik GmbH, Tech. Mitt. Krupp-Werksberichte, 41 (2), pp 51-68 (1983) 22 figs, 3 tables, 12 refs

(In German)

Key Words: Construction equipment, Excavators, Modal analysis, Finite element technique

Theoretical and experimental investigations of a bucket wheel excavator are presented and show that it is possible to predict the resonant excitation; e.g., dumping frequency in beat with bucket engagement frequency, sufficiently accurately by means of a finite element program. However, measured accelerations of the actual equipment are about 5-15% higher than predicted. They are caused by the natural frequencies of the equipment, which are excited by various operational conditions. Therefore, to prevent dangerous resonant vibrations, the appropriate additional excitations have to be taken into consideration during calculation.

POWER PLANTS

(Also see Nos. 2513, 2595, 2598)

84-2400

Leakage-Flow Induced Vibrations of a Chimney Structure Suspended in a Liquid Flow

H. Chung

Argonne National Lab., Argonne, IL 60439, Shock Vib. Bull., No. 54, Pt. 3, pp 123-133 (June 1984) 12 figs, 8 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Nuclear reactor components, Fluid induced excitation, Chimneys

This paper presents the results of flow-induced vibration tests conducted to assess the vibration characteristics of a chimney structure suspended in a liquid flow. The test article is a full-scale model of a flow chimney used in a nuclear reactor as a part of reactor upper internals. Tests were performed by simulating all pertinent prototype conditions achievable in a laboratory environment. The test results show that the chimney experiences an unstable, motion-limited vibration which has a distinct lock-in phenomenon with respect to the flowrate.

84-2401
Flow-Induced Vibration for Light Water Reactors. Program Final Report
J.E. Corr
General Electric Co., San Jose, CA, Rept. No. DOE/ET/34209-32, GEAP-22274, 302 pp (Mar 1983)
DE84004623

Key Words: Nuclear reactors, Fluid-induced excitation, Cylinders, Tube arrays

The Flow-Induced Vibrations for Light Water Reactors Program was a five-year effort to develop basic knowledge and understanding needed to improve the flow-induced vibration design of light water reactors. Major tasks included analytical and test investigations of the flow-induced vibration of cylinders in isolation and arrays in smooth and turbulent single-vibration testing of reactor components including reactor inlet plenum components, jet pumps, low-pressure coolant injection coupling, and fuel rods.

84-2402
Possibilities and Limitations of Monitoring Mechanical Vibrations
L. Pecinka
Zavod Vystavba Jadernych Elektraren, Skoda, Pilsen, Czechoslovakia, Rept. No. ZJE-258, 11 pp (1982)
DE83703886

Key Words: Diagnostic techniques, Nuclear reactors

The philosophy and main principles are described of current mathematical models for the description of mechanical vibrations of parts of PWR reactors. All mathematical models proceed from a common equation of motion and replace actual systems with many degrees of freedom by simpler systems. This determines the possibilities of diagnosing mechanical vibrations. The main restrictions for monitoring mechanical vibrations are due to the relationship between the monitoring system and the superior system.

84-2403
Dynamic Behaviour of Reactor Structures Subjected to Impulsive Loads
S.-I. Suzuki
Tsujido-Higashikaigan 2-17-21, Fujisawa, 251 Japan, J. Sound Vib., 93 (3), pp 365-370 (Apr 8, 1984) 3 figs, 1 table, 2 refs

Key Words: Nuclear reactor components, Plates, Cylinders, Time-dependent excitation

A reactor is modeled as a thin cylinder with one end capped by a solid circular plate and the dynamic behavior of this structure is investigated when it is subjected to an impulsive load uniformly distributed over the circular plate. To simplify calculations, the load is assumed to be a step function with respect to time. As the fundamental equation of the cylinder under an axisymmetrical load, Donnell's equation is used and it is solved by the Laplace transformation method.

84-2404
Seismic Design Technology for Breeder Reactor Structures. Volume 1. Special Topics in Earthquake Ground Motion
D.P. Reddy
Agbabian Associates, El Segundo, CA, Rept. No. DOE/SF/01011-T25-V.1, 275 pp (Apr 1983)
DE84004808

Key Words: Nuclear reactors, Seismic design

This report is divided into twelve chapters: seismic hazard analysis procedures, statistical and probabilistic considerations, vertical ground motion characteristics, vertical ground response spectrum shapes, effects of inclined rock strata on site response, correlation of ground response spectra with intensity, intensity attenuation relationships, peak ground acceleration in the very mean field, statistical analysis of response spectral amplitudes, contributions of body and surface waves, evaluation of ground motion characteristics, and design earthquake motions.

OFF-SHORE STRUCTURES

(Also see Nos. 2489, 2523)

84-2405
In-Plane Ice Structure Vibration Analysis by Two-Dimensional Elastic Wave Theory
C.H. Luk
Exxon Production Research Co., Houston, TX 77001, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 160-168 (June 1984) 13 figs, 2 refs

Key Words: Ice, Off-shore structures, Vibration analysis

A theoretical analysis of an in-plane ice sheet vibration problem due to a circular cylindrical structure moving in the

plane of an infinite ice sheet is presented and the ice forces exerted on the structure as the motion occurs are computed. The basic equations are derived from two-dimensional elastic wave theory for a plane stress or plane strain problem. The ice material is treated as a homogeneous, isotropic and linear elastic solid. The resulting initial and boundary value problems are described by two wave equations.

84-2406

Summer Ice Floe Impacts Against Caisson-Type Exploratory and Production Platforms

P. Croteau, M. Rojansky, and B.C. Gerwick

Lavalin Offshore, Inc., St. John's, Newfoundland, Canada, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 169-175 (June 1984) 7 figs, 1 table, 20 refs

Key Words: Off-shore structures, Drilling platforms, Ice

Summer impacts of large ice floes against arctic offshore platforms are likely to be a governing condition for the global foundation stability in medium and deep-water offshore platforms in the Alaskan Beaufort Sea. Some features of the impact phenomenon are illustrated by analyzing two vertically faced caisson-type gravity platforms. The two structures differ in their function, size and environmental exposure.

84-2407

Subharmonic and Chaotic Motions of Compliant Offshore Structures and Articulated Mooring Towers

J.M.T. Thompson, A.R. Bokaian, and R. Ghaffari

University College London, London, UK, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 191-198 (June 1984) 11 figs, 16 refs

Key Words: Off-shore structures, Towers, Moorings, Subharmonic oscillations, Resonant response

Compliant offshore structures have complex nonlinear dynamics. Subharmonic resonances can co-exist with small fundamental motions. To prevent a simulation missing an entire subharmonic peak, a comprehensive set of initial conditions must be explored. Chaotic nonperiodic motions can also arise in deterministic problems. These are extremely sensitive to starting conditions and require a statistical description. Chaotic responses and their adjacent subharmonics of arbitrarily high order mean that the duration of digital, analogue and laboratory simulations must be chosen with considerable care. Resonances of articulated mooring towers, encountered in tank tests, are used to illustrate these general concepts.

84-2408

The Motions of Adjacent Floating Structures in Oblique Waves

N. Kodan

Tsu Res. Labs., Technical Res. Ctr., Nippon Kokan K.K. Japan, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 199-205 (June 1984) 10 figs, 21 refs

Key Words: Off-shore structures, Floating structures, Wave forces

A theory on the effects of hydrodynamic interaction between two parallel slender structures in oblique waves is described. The method is based on the two-dimensional diffraction theory including the interaction effect. Numerical results of the wave exciting force and moment and motions for the case of a combination of a ship and a rectangular barge are presented and compared with the results from model experiments.

84-2409

Requirements for a Nondestructive Inspection System for the Hutton Tension Leg Platform (TLP) Mooring System

N.W. Hein, Jr., F. Skilbeck, B.P. Herd, and A.J. DeVries

Conoco, Inc., Ponca City, OK 74601, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 260-265 (June 1984) 15 figs, 12 refs

Key Words: Off-shore structures, Drilling platforms, Moorings, Fatigue life, Nondestructive tests

The mooring system is one of the most critical and novel aspects of the Hutton tension leg platform (TLP) design. The tension lines of the TLP mooring system are subjected to severe fatigue loading conditions making the continuous assessment of their integrity an essential part of the production operation. This paper outlines the inspection requirements for the tension legs. The various concepts considered for the in-situ inspection are also discussed.

84-2410
Nonlinear Inertia Forces on Slender Cylindrical Members
A.N. Williams
Dept. of Mathematics, Oregon State Univ., Corvallis, OR 97331, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 222-225 (June 1984) 1 fig, 4 tables, 18 refs

Key Words: Underwater structures, Cylinders, Wave forces

An expression for the nonlinear wave force on a vertical, circular cylindrical member whose diameter is small compared to the incident wavelength is derived from an exact solution to the second-order diffraction problem. A comparison is then made with the inertial force estimates obtained using Stokes' second and fifth-order wave theories in Morison's equation with a mass coefficient derived from linear potential theory, as is currently recommended in the offshore design codes.

84-2412
Crash Tests of Portable Concrete Median Barrier for Maintenance Zones
J.S. Fortuniewicz, J.E. Bryden, and R.G. Phillips
Engrg. Res. and Dev. Bureau, New York State Dept. of Transportation, Albany, NY, Rept. No. FHWA/NY/RR-82/102, 43 pp (Dec 1982)
PB84-179902

Key Words: Collision research (automotive), Guardrails

A shorter, more portable concrete median barrier was evaluated through full-scale crash tests. Test results were generally good in terms of vehicle accelerations and occupant-vehicle impact velocities. Vehicle reactions were somewhat violent, especially in the 25 degree impacts, demonstrating the severity of high-angle impacts with rigid barriers. Smooth barrier surface textures appear to be important for minimizing vehicle roll angles.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see No. 2375)

84-2411
Improvements in Rail Vehicle Dynamic Performance through Control of Linear Motor Lateral and Normal Forces
R.J. Caudill, L.M. Sweet, W.L. Garrard, B.S. Heck, and P. Garrison
Princeton Univ., NJ, Rept. No. DOT/RSPA/DMA-50/84/15, 224 pp (Oct 1983)
PB84-182351

Key Words: Railroad trains, Ride dynamics

The objective of this research is to examine the use of linear motors for improving the lateral dynamic performance of railroad vehicles. The potential for improved vehicle stability, ride quality, traction capability, curving performance, track loading, and derailment safety results from the use of controllable lateral and normal magnetic forces present in the motor in addition to those used for propulsion. In this study recent advances in technology originally for high-speed levitated vehicles are applied to conventional railroad vehicles resulting in a system which has a higher potential for near-term implementation.

84-2413
Some Aspects of Motorcycle Noise Emission
P.M. Nelson and N.F. Ross
Transport and Road Res. Lab., Crowthorne, UK, Rept. No. TRRL-SUPPLEMENTARY-795, 30 pp (1983)
PB84-166263

Key Words: Motorcycles, Acoustic emission, Noise measurement

This report compares the noise emission characteristics of motorcycles with noise emission for other vehicle types and attempts to evaluate the relevance of standard methods of measuring motorcycle noise emission for regulation test purposes.

84-2414
Comparison of the Directional Dynamics of Tractor-Semitrailer and Truck-Trailer Combinations during a Sudden Change in Steering Angle (Vergleich des Fahrverhaltens von Sattel-und Lastzügen beim Lenkwinkelsprung)
F. Vlk
Mokrohorska 34, CS-64400 Brno, CSSR, Automobiltech. Z., 86 (4), pp 193, 194, 197, 198, 201, 202 (Apr 1984) 9 figs, 6 refs
(In German)

Key Words: Articulated vehicles, Trailers, Ride dynamics

A linear mathematical model has been developed for studying the directional response of tractor-semitrailer and truck-trailer combinations. All elements of the articulated vehicles in the model were assumed to behave as rigid bodies in a horizontal plane. Transient functions were used to express the directional dynamic performance of various vehicle combinations. These characteristics represent the handling of a vehicle system excited by a sudden change in the steering angle input of the front wheels of the tractor or the truck.

84-2415

The Changing Vibration Simulation for Military Ground Vehicles

J. Robinson

Materials Testing Directorate, Aberdeen Proving Ground, MD, Shock Vib. Bull., No. 54, Pt. 1, pp 113-124 (June 1984) 8 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Standards and codes, Vibration tests, Ground vehicles, Military vehicles

Many changes in laboratory test schedules are found in MIL-STD-810D. One particular area of the MIL-STD which has undergone a pronounced change is the laboratory vibration simulation of secured cargo transport in military ground vehicles. The intent of this paper is to examine why and how these changes have taken place, the impact of these changes, and what is needed to adequately accommodate them.

84-2416

Stability of Vehicles Moving on an Elastic Foundation

L. Jezequel

Departement de Mecanique des Solides, Ecole Centrale de Lyon, Ecully - 69130, France, J. Sound Vib., 93 (4), pp 567-583 (Apr 22, 1984) 15 figs, 29 refs

Key Words: Ground vehicles, Elastic foundations, Flutter, Stability

Few studies have been made of the stability of a dynamic system moving on an infinite continuum. Here a general method of analysis of such coupled systems is presented. It shows that vehicles possessing a single point of contact with the foundation become unstable above a velocity always higher than the critical speed defined in the classical constant moving force problem.

SHIPS

(Also see No. 2466)

84-2417

An Ultrasonic Technique for Non-Destructive Testing of Butt Welded Steel Plate in Ship Hulls

M.A. Hamed and R. Contreras

Univ. of New Orleans, New Orleans, LA 70148, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 634-641, 9 figs, 1 table, 15 refs

Key Words: Ship hulls, Plates, Nondestructive tests, Ultrasonic techniques

The subject of this research is the development of convenient specimen configuration with an induced crack in the vicinity of welds. The specimen is used to verify a nondestructive testing method involving ultrasonic waves in underwater driverheld ship hull weld inspection. Existing methods of ship hull ultimately involve placing ships in dry-dock. A method is proposed in ship hull inspection which would allow for more definite decision making regarding the need for dry-docking.

84-2418

Shipboard Shock Response of the Model Structure DSM; Experimental Results Versus Responses Predicted by Eight Participants

R. Regoord

Delft, The Netherlands, Shock Vib. Bull., No. 54, Pt 2, pp 43-65 (June 1984) 29 figs, 11 tables (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shipboard equipment response, Shock response, Prediction techniques

A simple structure was shock tested and both the input and the three dimensional response were measured. Using only the input, the response was predicted as well by eight sup-

pliers, shipyards, etc. The results of this participation which were obtained with different methods and computer programs, are described.

analytical methods for predicting accelerations, velocities, and displacements of collapsing structures are also discussed.

AIRCRAFT

(Also see No. 2563)

84-2419

Body-Freedom Flutter of a 1/2-Scale Forward-Swept-Wing Model, an Experimental and Analytical Study

R. Chipman, F. Rauch, M. Rimer, and B. Muniz

Grumman Aerospace Corp., Bethpage, NY, Rept. No. LD-10-901-164, NASA CR-172324, 257 pp (Apr 1984)

N84-21553

Key Words: Aircraft vibration, Flutter

The aeroelastic phenomenon known as body-freedom flutter (BFF), a dynamic instability involving aircraft-pitch and wing-bending motions which, though rarely experienced on conventional vehicles, is characteristic of forward swept wing (FSW) aircraft was investigated. Testing was conducted in a transonic dynamics tunnel *on a flying,* cable-mounted, 1/2-scale model of a FSW configuration with and without relaxed static stability. The BFF instability boundaries were found to occur at significantly lower airspeeds than those associated with aeroelastic wing divergence on the same model.

84-2420

Survey of NASA Research on Crash Dynamics

R.G Thomson, H.D. Carden, and R.J. Hayduk

NASA Langley Res. Ctr., Hampton, VA, Rept. No. L-15757, NASA-TP-2298, 46 pp (Apr 1984)

N84-21901

Key Words: Crash research (aircraft)

Ten years of structural crash dynamics research activities conducted on general aviation aircraft by the National Aeronautics and Space Administration are described. Thirty-two full-scale crash tests were performed and pertinent data on airframe and seat behavior were obtained. Concurrent with the experimental program, analytical methods were developed to help predict structural behavior during impact. Computer programs which provide designers with

84-2421

Aircraft Crash Dynamics Research Update

G. Wittlin

Lockheed-California Co., Burbank, CA 91520, Shock Vib. Dig., 16 (6), pp 11-21 (June 1984) 14 figs, 26 refs

Key Words: Aircraft, Crash research (aircraft), Reviews

Three major considerations of aircraft crash dynamics research include aircraft crash environments, available analytical techniques, and occupant protection. This article presents an update of these considerations with regard to recent research efforts in aircraft structural crash dynamics. The results of an accident history review of large transport airplanes conducted by three major domestic transport airplane manufacturers, and sponsored by the Federal Aviation Administration and National Aeronautics and Space Administration, are presented. Modeling and testing of transport airplane structure are discussed. Recent analyses and tests of helicopter composite fuselage structure are reviewed. Summary reports of general aviation aircraft crash-tests *from the NASA-Langley Impact* Dynamics Facility are noted. The status of seat-occupant modeling for light aircraft is presented.

84-2422

Wind Tunnel Correlation Study of Aerodynamic Modeling for F/A-18 Wing-Store Tip-Missile Flutter

W.E. Triplett

McDonnell Aircraft Co., St. Louis, MO, J. Aircraft, 21 (5), pp 329-334 (May 1984) 11 figs, 3 tables, 7 refs

Key Words: Aircraft wings, Wing stores, Flutter

Wind tunnel testing of the F/A-18 wing with underwing stores and tip missile discovered several cases of flutter for which acceptable correlation was not obtained by adjustment of stiffness and mass. Studies were conducted to evaluate the effect of aerodynamic modeling on three of the uncorrelated cases using the doublet-lattice theory. Results are presented showing the effect of individual system components on flutter.

84-2423

The Fluid Mechanics of Slender Wing Rock

L.E. Ericsson

Lockheed Missiles & Space Co., Inc., Sunnyvale, CA, J. Aircraft, 21 (5), pp 322-328 (May 1984) 14 figs, 25 refs

Key Words: Aircraft wings, Vortex shedding, Fluid-induced excitation

The limit cycle oscillation in roll of very slender delta wings, the so called wing rock, is caused by asymmetric vortex shedding from the wing leading edges and not by vortex burst. The breakdown or burst of the leading edge vortices of a delta wing can lead to static instability with associated roll divergence. Vortex burst however, can never be the cause of wing rock, because it has a dynamically stabilizing effect on the roll oscillations. Consequently, slender wing rock is only realized for delta wings with more than 74-deg leading-edge sweep, in which case vortex asymmetry occurs before vortex breakdown. A careful analysis of available experimental data reveals the fluid mechanical process that generates slender wing rock.

84-2424

Test-Engine and Inlet Performance of an Aircraft Used for Investigating Flight Effects on Fan Noise

R.A. Golub and J.S. Preisser

NASA Langley Res. Ctr., Hampton, VA, Rept. No. L-15653, NASA-TP-2254, 70 pp (Apr 1984) N84-21277

Key Words: Aircraft engines, Noise measurement, Fan noise, Measuring instruments, Measurement techniques

As part of the NASA Flight Effects on Fan Noise Program, a Grumman OV-1B Mohawk aircraft was modified to carry a modified and instrumented Pratt & Whitney JT15D-1 turbofan engine. Onboard flight data, together with simultaneously measured farfield acoustic data, comprise a flight data base to which JT15D-1 static and wing-tunnel data are compared. The overall objective is to improve the ability to use ground-based facilities for the prediction of flight inlet radiated noise. This report describes the hardware and presents performance results for the research engine.

84-2425

Limit Cycle Oscillations of a Nonlinear Rotorcraft Model

B.H. Tongue

Georgia Inst. of Tech., Atlanta, GA, AIAA J., 22 (7), pp 967-974 (July 1984) 13 figs, 9 refs

Key Words: Helicopters, Dynamic stability, Stability, Nonlinear damping

Previous studies of helicopter stability have focused on a linear formulation of the system. This paper addresses the stability question from a nonlinear standpoint. The limit cycle behavior of a rotorcraft having a nonlinear damping characteristic is examined. The effect of parameter variations on the system's response is discussed and differences between a linear and nonlinear model are presented.

MISSILES AND SPACECRAFT

(Also see Nos. 2456, 2457, 2576)

84-2426

Generalized Modal Shock Spectra with Indeterminate Interface

M. Salama, M. Trubert, C. Chian, and L. Peretti

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, AIAA J., 22 (6), pp 824-830 (June 1984) 2 figs, 1 table, 9 refs

Key Words: Spacecraft, Modal analysis, Shock response spectra

The generalized modal shock spectra method has proved to be an effective tool in reducing the analysis effort and degree of dependence between the spacecraft and launch vehicle design processes. However, the method has limitations on the degree of structural static determinancy of the spacecraft to launch vehicle interface. These practical limitations are removed in the present work by using the "interface modes." The governing differential equations are first derived and are shown to be valid for either integrating the modal models of two or more substructures that have been previously obtained separately, or for removing a substructure from a previously available system modal model. These equations facilitate investigating the effects of interchanging payloads on the systems response.

84-2427

Water Impact Laboratory and Flight Test Results for the Space Shuttle Solid Rocket Booster Aft Skirt

D.A. Kross, N.C. Murphy, and E. A. Rawls

NASA/Marshall Space Flight Ctr., Marshall Space Flight Ctr., AL, Shock Vib. Bull., No. 54, Pt. 2, pp

87-98 (June 1984) 22 figs, 3 tables (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Booster rockets, Space shuttles, Impact tests, Impact response, Water, Foams

A series of water impact tests has been conducted using full-scale segment representations of the Space Shuttle Solid Rocket Booster (SRB) aft skirt structure. The baseline reinforced structural design was tested as well as various alternative design concepts. A major portion of the test program consisted of evaluating foam as a load attenuation material.

84-2428

Transient Vibration Test Criteria for Spacecraft Hardware

D.L. Kern and C.D. Hayes

Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA, Shock Vib. Bull., No. 54, Pt. 3, pp 99-109 (June 1984) 7 figs, 4 tables, 4 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons SVIC, Naval Res. Lab., Washington, DC)

Key Words: Spacecraft equipment response, Vibration tests, Launching response

Transient vibration test criteria have been developed for spacecraft hardware. The test criteria provide a test rationale to verify the capability of the hardware to withstand the low and mid-frequency transient vibration environments induced by launch vehicle events. The traditional test method employed to simulate transient vibration environments, the slow swept sine, results in excessive resonant response build-up and an excessive number of vibration cycles as compared to the actual transient flight environment. A unique test method, consisting of a series of discrete frequency, limited cycle, modulated sine wave pulses, was developed to avoid the slow swept sine drawbacks, yet provide a repeatable test that would excite all frequencies.

84-2429

Vibration Control of Space Structures VCOSS A: High and Low-Authority Hardware Implementations

J N. Aubrum, C.Z. Gregory, M.G. Lyons, R.L. Kosut, and A.A. Woods, Jr.

Lockheed Missiles and Space Co., Inc., Sunnyvale, CA, Rept. No. LMSC-D883019, AFWAL-TR-83-3074, 277 pp (July 1983)
AD-A139 931

Key Words: Spacecraft, Vibration control

The report considers some hardware aspects of large space structure control implementations. Hardware and system performance requirements are overviewed, principally in the context of vibration suppression. Analytical models are used to evaluate vibration suppression performance for actively controlled and passive structures.

84-2430

Vibration Control of Space Structures VCOSS B: Momentum Exchange and Truss Dampening

L. Brady, G. Franco, L. Keranen, J. Kern, and R. Neiswander

TRW Space and Technology Group, Redondo Beach, CA, Rept. No. AFWAL-TR-83-3075, 110 pp (July 1983)
AD-A139 910

Key Words: Spacecraft, Vibration control, Active vibration control

This report presents the final technical results of the TRW Vibration Control of Space Structures (VCOSS) program. Subtasks include: dynamic performance studies of a vibration controlled structure, design iterations, graphic representation of system performance (LOS errors), comparison of active controlled to stiffness controlled model.

84-2431

Mechanical Properties of the Shuttle Orbiter Thermal Protection System Strain Isolator Pad

J.W. Sawyer

NASA Langley Res. Ctr., Hampton, VA, J. Spacecraft Rockets, 21 (3), pp 253-260 (May/June 1984) 19 figs, 1 table, 8 refs

Key Words: Space shuttles, Heat shields, Fatigue life, Experimental data

An experimental investigation has been conducted to determine the static and fatigue properties of the Strain Isolator Pad (SIP) used on the shuttle orbiter thermal protection

system. Static tension-compression, and shear test results show that the SIP is highly nonlinear, has a large hysteresis, a large low-modulus region for low stress levels, and stress-strain properties that are highly sensitive to strain rate and previous load history. In addition, the shear properties are also sensitive to forces applied normal to the plane of the pad and to the orientation of the material.

84-2432
Environmental Effects on the Dynamics and Control of an Orbiting Large Flexible Antenna System
R. Krishna and P.M. Bainum
Howard Univ. Washington, DC, Rept. No. NASA CR-175448, 10 pp (1984)
N84-20627

Key Words: Spacecraft antennas, Temperature effects

Solar radiation pressure on the vibrating antenna structure, temperature gradients induced by solar heating, and stabilizing gravity-gradient torques were considered when the linear regulator theory was used to obtain orientation and shape control of a hoop/column antenna system being considered for the land mobile satellite system. A finite element model of the antenna system which includes all six rigid modes and seven flexible modes was used. Results show that the environmental disturbances affect only the rigid modes of the structure.

BIOLOGICAL SYSTEMS

HUMAN

84-2433
Aircraft and Background Noise Annoyance Effects
K.F. Willshire
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-85744, 31 pp (Jan 1984) (Presented at Human Factors Soc., Ann. Mtg., Norfolk, VA, Oct 10-14, 1983)
N84-19051

Key Words: Aircraft noise, Human response

To investigate annoyance of multiple noise sources, two experiments were conducted. The first experiment, which used 48 subjects, was designed to establish annoyance-noise level functions for three community noise sources presented individually: jet aircraft flyovers, air conditioner, and traffic. The second experiment, which used 216 subjects, investigated the effects of background noise on aircraft annoyance as a function of noise level and spectrum shape; and the differences between overall, aircraft, and background noise annoyance.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS

84-2434
Computer Simulation of a Shock-Absorbing Pneumatic Cylinder
Y.T. Wang, R. Singh, H.C. Yu, and D.A. Guenther
Dept of Mech. Engrg., Ohio State Univ., Columbus, OH 43210, J. Sound Vib., 93 (3), pp 353-364 (Apr 8, 1984) 4 figs, 5 tables, 19 refs

Key Words: Shock absorbers, Pneumatic shock absorbers, Simulation

A mathematical simulation model of a double-acting pneumatic cushioning cylinder, designed to absorb periodic shock loads, is presented, which is based on the following assumptions: ideal equation of state, isentropic flow through a port-bleed orifice, isentropic compression process, single degree of freedom piston-cylinder dynamics, and the energy-equivalent linear damping. A computer simulation model is employed to predict pressure and motion time histories, and cylinder performance indices. Predictions for both untuned and tuned cylinder example cases are compared with measurements.

84-2435
Two-Dimensional Shock Response of a Mass on Energy-Absorbing Shock Mounts
R.E. Fortuna and V.H. Neubert
Pennsylvania State Univ., University Park, PA 16802, Shock Vib. Bull., No. 54, Pt. 2, pp 1-11 (June 1984) 21 figs, 2 tables, 5 refs (Proc. Shock Vib. Symp.,

Oct 18-20, 1983 Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock absorbers, Rings, Steel

Results of experimental and analytical studies of side-loaded, annealed, low carbon steel rings used as shock mounts are presented. The purpose of the present work was to obtain experimental data and carry out an associated analysis for the rings under combined loading, in compression (or tension) and roll.

84-2436

Optimum Design for Nonlinear Shock Mounts for Transient Inputs

K. Kasraie and V.H. Neubert

Central Res. Lab., Firestone Tire & Rubber Co., Akron, OH 44317, Shock Vib. Bull., No. 54, Pt. 2, pp 13-28 (June 1984) 20 figs 6 tables, 18 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC Naval Res. Lab., Washington, DC)

Key Words: Shock absorbers Optimum design

The state space method for optimal design of vibration isolators is used and advanced to include a more general class of problems encountered in the optimal design of shock absorbers. Sixteen different shock absorbers with viscous damping and a bi-linear spring are designed for optimum response to a shock of finite duration imposed by the supporting base.

84-2437

On Optimal Support Reaction in Viscoelastic Vibrating Structures

T. Lekszycki and Z. Mroz

Inst. of Fundamental Technological Res., Warsaw, Poland, J. Struc. Mech., 11 (1), pp 67-79 (1983) 5 figs, 5 refs

Key Words: Supports, Beams, Frames, Viscoelastic properties

For a viscoelastic beam or frame structure that undergoes forced vibrations, the conditions for optimal support reaction are derived. Translation or rotation of supports are allowed and a functional expressed in terms of stress or strain amplitudes is minimized. Optimality conditions are derived using the concept of an adjoint structure and an illustrative example is presented for the case of beam vibration.

84-2438

Impact and Vibration Testing of Shipping Containers

K. Peleg

Dept. of Agricultural Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Sound Vib., 93 (3), pp 371-388 (Apr 8, 1984) 6 figs, 2 tables, 9 refs

Key Words: Shipping containers, Impact tests, Vibration tests, Corrugated structures, Restoring factors, Dissipation factor, Viscous damping, Coulomb friction

Equations are developed for experimental evaluation of restoring and dissipative parameters, as used in a nonlinear mathematical unit load model. A specially developed transportation damage simulation test jig is described. This jig is suitable for impact and vibration load reproduction on bottom tier containers in unit loads, but only a single container sample is needed. A detailed case study is described, exemplifying how these parameters may be evaluated by impact (shock) or vibration testing of corrugated produce shipping containers.

84-2439

Vibrational Loading Mechanism of Unitized Corrugated Containers with Cushions and Non-Load-Bearing Contents

T.J. Urbanik

Forest Products Lab., Forest Service, U.S. Dept. of Agriculture, Madison, WI, Shock Vib. Bull., No. 54, Pt. 3, pp 111-121 (June 1984) 6 figs, 2 tables, 11 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Containers, Shipping containers, Corrugated structures, Transportation effects

The use of hardwood and recycled fiber will no doubt increase as specifications for corrugated fiberboard containers change from material to performance standards. This report shows another way to accelerate this use by reducing the strength requirements of containers shipped in unitized loads. The rate of container deformation with top loading and the compliance of internal packing material or cushions are newly identified variables governing the compression of bottom containers.

84-2440

Gear Case Vibration Isolation in a Geared Turbine Generator

R.P. Andrews

Marine Div., Westinghouse Electric Corp., Sunnyvale, CA, Shock Vib. Bull., No. 54, Pt. 3 pp 59-65 (June 1984) 5 figs, 4 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Mountings, Gearboxes

The design and analysis of a flexible gear case mount system for a geared turbine generator is presented. The mount system isolates gear case vibration and allows the gear bearing loads to be equalized. The primary excitation frequencies to be isolated are the pinion rotational harmonics. Dynamic mathematical modeling was used to determine the proper mount flexibility relative to the inertia properties and flexibility of the system components.

84-2441

An Experimental Study on the Vibration Response of Traction Motor Suspension System

M. Ghosh, A.S. Panwalkar, and A. Rajamani

Vib. Lab., Bharat Heavy Electricals Limited, Vikasnagar, Hyderabad-500 593, India, Intl. Congress on Exptl. Mechanics Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 406-411, 7 figs, 1 table, 6 refs

Key Words: Suspension systems (vehicles), Traction drives, Railroad trains, Acceleration measurement

Dynamic performance of a traction motor suspension system is evaluated experimentally under various operating parameters. A comparative analysis of average peak and maximum peak acceleration values is made for new and old motors. Results for the number of cross-overs above specified acceleration levels with speed are presented.

84-2442

Dynamic Response Study of a Traction Motor and Suspension System Model

A.S. Panwalkar

Vib. Lab. Corporate Res. and Dev. B.H.E.L., Vikasnagar, Hyderabad-500593, India, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 571-578, 6 figs, 4 tables, 2 refs

Key Words: Suspension systems (vehicles), Traction drives, Railroad trains, Locomotives, Stiffness coefficients, Natural frequencies

The variation of natural frequencies of a traction motor model and its suspension with respect to stiffness parameters of different suspension springs is determined. The theoretical and experimental results obtained are in good agreement. The influence of variation of secondary spring stiffness on natural frequencies is also studied.

84-2443

The Experimental Performance of an Off-Road Vehicle Utilizing a Semi-Active Suspension

E.J. Krasnicki

Lord Corp., Erie, PA, Shock Vib. Bull., No. 54, Pt. 3, pp 135-141 (June 1984) 6 figs, 4 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Semiactive isolation, Suspension systems (vehicles), Off-highway vehicles

The transition of the semi-active suspension system from an operating laboratory prototype into an operational off-road vehicle prototype, which utilizes a self contained semi-active suspension system, is presented. The modified vehicle and a stock vehicle, with a conventional passive suspension system, are compared on a designated test course. The experimental performance results of the On-Off semi-active system and the conventional system are compared and discussed.

84-2444

Structural Modifications by Viscoelastic Elements

P.J. Riehle

Anatrol Corp., Cincinnati, OH, Shock Vib. Bull., No. 54, Pt. 3, pp 1-10 (June 1984) 15 figs, 9 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Isolation, Joints (junctions), Viscoelastic properties, Mechanical impedance

A modeling technique which predicts the reduction in vibration transmitted from one structure to another through a viscoelastic isolation system is described. Analytical or

experimental representations of structure compliances and viscoelastic element stiffness and damping values are used in the analysis. Predicted results of an isolation system are presented and compared to experimentally obtained results.

84-2445

The Influence of Attachments of Dynamic Characteristics of Engine Blocks (Einflüsse von Anbauteilen auf die dynamischen Kenngrössen von Motorblöcken)

J. Affenzeller, H.H. Priebsch, and G. Rainer

Grazerstrasse 44, A-8045, Graz Austria, MTZ Motortech. Z., 45 (1), pp 5-9 (Jan 1984) 10 figs, 5 refs (In German)

Key Words: Engine mounts, Diesel engines, Design techniques

Components such as cylinderhead, oil pan, bearing bridge and crank mechanism can significantly influence the dynamic characteristics of an engine design or an engine block. The objective of this research work was to determine the extent of such influences on the engine block dynamics of various diesel engines for passenger cars and trucks.

TIRES AND WHEELS

84-2446

Experimental Study of the Noise Generated by a Passenger Automobile Equipped with Studded and Regular Snow Tyres

M. Hasebe

Hokkaido Res. Inst. for Environmental Pollution, Nishi-12, Kita-19, Kita-ku, Sapporo 060, Japan, Appl. Acoust., 17 (4), pp 247-254 (1984) 6 figs, 1 table, 3 refs

Key Words: Automobile tires, Studded tires, Noise generation

Studded snow tires are used to prevent automobiles from slipping on ice-covered roads. In this paper the noise generated by a passenger automobile equipped with studded snow tires is studied and compared with the noise generated when regular snow tires are used.

84-2447

Rim Section Fatigue Properties of a Cast Aluminum Wheel

D.C. Wei

Kelsey-Hayes Co., Ann Arbor, MI 48105, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 599-604, 6 figs, 10 refs

Key Words: Wheels, Aluminum, Fatigue life

A rim section fatigue testing technique was employed to evaluate the actual fatigue properties of a low pressure permanent mold cast aluminum wheel which was made of cast aluminum alloy A356-T6. Finite element method was employed to determine the stress levels corresponding to the test loads used during the test.

BLADES

84-2448

Formulation of Blade-Flutter Spectral Analyses in Stationary Reference Frame

A.P. Kurkov

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. E-1888, NASA-TP-2296, 32 pp (Mar 1984)
N84-20562

Key Words: Blades, Flutter, Spectrum analysis

Analytic representations are developed for the discrete blade deflection and the continuous tip static pressure fields in a stationary reference frame. Considered are the sampling rates equal to the rotational frequency, equal to a multiple of the blade passing frequency. A procedure is presented for transforming the complete unsteady pressure field into a rotating frame of reference. The determination of the true flutter frequency by using two sensors is described.

84-2449

Parametric Study of Turbine Blade Platform Friction Damping Using the Lumped Parameter Analysis

R.J. Dominic

Univ. of Dayton Res. Inst., OH, ASME Paper No. 84-GT-109

Key Words: Blades, Turbine blades, Hysteretic damping, Lumped parameter method

The parametric study considers the effects on the blade deflection response of variations in the coefficient of friction; the normal force on the friction surface interface; the blade hysteretic damping; the blade-to-blade phase angle of the harmonic forcing function; and the amplitude of the forcing function. The results are applicable to any blade-damper system similar to the one used in the study.

84-2450

Vibration of Impellers (5th Report, Measurement of Resonant Vibratory Stresses of an Impeller and Pressure Distribution Due to Aerodynamic Excitation)

S. Michimura, A. Nagamatsu, T. Ishikawa, and H. Yamaguchi

Tokyo Inst. of Tech., 2-12-1 Ohokayama Meguro-ku Tokyo (152), Japan, Bull. JSME, 27 (225), pp 534-539 (Mar 1984) 10 figs, 3 refs

Key Words: Blades, Impellers, Aerodynamic loads, Vibration analysis

Impellers rotate at high speeds, and therefore in order to improve the efficiency of turbomachines it is necessary to take into account not only the static strength to withstand the centrifugal force but also the dynamic strength to withstand vibration in the design stage. In practice various kinds of exciting forces are applied to impellers, but in this investigation a screen with slots around its periphery is positioned in front of the impeller and the impeller is excited aerodynamically through this screen. The resonant vibratory stresses and the pressure distribution are measured simultaneously in resonant condition when the impeller is rotating at high speeds. The relationship between the resonant vibratory stresses and the pressure distribution is discussed in detail by analyzing the frequency variation of the two components.

84-2451

The Effect of Thermal Transients on Radial Turbine Blade Vibration Damping – A Case History

T. Naess and K.O. Teien

Kongsberg Gas Turbines and Power Systems Div., Norway, ASME Paper No. 84-GT-110

Key Words: Blades, Turbine blades, Joints (junctions), Resonant response

It is shown how the influence of an interference fit or dampening joint between the two rotor wheels was actually hiding the possible resonance condition during the initial qualification tests, and how the transient movements of this joint would allow resonance to occur under certain operational conditions.

84-2452

Characteristics of Natural Frequencies of Steam Turbine Blades (1st Report, Relationship on Vibration Between Grouped Blades and Disk)

M. Shiga

Hitachi Ltd., Kandatsu, Tsuchiura, Ibaraki, Japan, Bull. JSME, 27 (226), pp 802-808 (Apr 1984) 12 figs, 12 refs

Key Words: Blades, Turbine blades, Natural frequencies, Disks

The fundamental nature of the natural frequencies of blades and disk system is studied using a model of the axial vibration of steam turbine blades. The relationship between the vibrations of grouped blades and the disk is discussed in detail. The relations between the number of nodal diameters and the natural frequencies and the transition of natural frequencies according to the change of blade length are clarified.

84-2453

Influence of Gyroscopic Forces on the Dynamic Behavior and Flutter of Rotating Blades

F. Sisto and A.T. Chang

Stevens Inst. of Tech., Hoboken, NJ, Rept. No. ME-RT-82006, NASA-CR-175444, 118 pp (Dec 1983) N84-20524

Key Words: Blades, Rotor blades (turbomachinery), Cantilever blades, Flutter

The structural dynamics of a cantilever turbomachine blade mounted on a spinning and precessing rotor are investigated. Both stability and forced vibration are considered with a blade model that increases in complexity (and verisimillitude) from a spring-restrained point mass, to a uniform cantilever, to a twisted uniform cantilever turbomachine blade mounted on a spinning and precessing rotor are investigated.

84-2454

Space Shuttle Main Engine Powerhead Structural Modeling, Stress and Fatigue Life Analysis. Volume 1: Gasdynamic Environment of the SSME HPFTP and HPOTP Turbines

J.C. Hammett, C.H. Hayes, J.M. Price, J.K. Robinson, and G.A. Teal

Lockheed Missiles and Space Co., Inc., Huntsville, AL, Rept. No. LMSC-HREC-TR-D867333-1, NASA-CR-170999, 169 pp (Dec 1983)

N84-20635

Key Words: Blades, Turbine blades, Nozzles, Space shuttles, Fatigue life

Gasdynamic analysis for the turbine blades and nozzle vanes, HPFTP turbine analysis, and HPOTP turbine analysis are provided.

84-2455

Space Shuttle Main Engine Powerhead Structural Modeling, Stress and Fatigue Life Analysis. Volume 2: Dynamics of Blades and Nozzles SSME HPFTP and HPOTP

J.C. Hammett, C.H. Hayes, J.M. Price, J.K. Robinson, and G.A. Teal

Lockheed Missiles and Space Co., Huntsville, AL, Rept. No. LMSC-HREC-TR-D867333-II, NASA-CR-171000, 130 pp (Dec 1983)

N84-20636

Key Words: Blades, Turbine blades, Nozzles, Space shuttles, Fatigue life

Normal modes of the blades and nozzles of the HPFTP and HPOTP are defined and potential driving forces for the blades are identified. The computer models used in blade analyses are described, with results. Similiar information is given for the nozzles.

84-2456

Space Shuttle Main Engine Powerhead Structural Modeling, Stress and Fatigue Life Analysis. Volume 3: Stress Summary of Blades and Nozzles at FPL and 115 Percent RPL Loads. SSME HPFTP and HPOTP Blades and Nozzles

J.C. Hammett, C.H. Hayes, J.M. Price, J.K. Robinson, and G.A. Teal

Lockheed Missiles and Space Co., Inc., Huntsville, AL, Rept. No. LMSC-HREC-TR-D867333-III, NASA-CR-171001, 443 pp (Dec 1983)

N84-20637

Key Words: Blades, Turbine blades, Nozzles, Space shuttles, Fatigue life

Gasdynamic environments applied to the turbine blades and nozzles of the HPFTP and HPOTP were analyzed. Centrifugal loads were applied to blades to account for the pump rotation of FPL and 115 percent RPL. The computer models used in the blade analysis with results presented in the form of temperature and stress contour plots are described. Similar information is given for the nozzles.

84-2457

Space Shuttle Main Engine, Powerhead Structural Modeling, Stress and Fatigue Life Analysis. Volume 4: Summary of Investigation of Unscheduled Events and Special Tasks

J.K. Robinson, G.A. Teal, and C.T. Welch

Lockheed Missiles and Space Co., Inc., Huntsville, AL, Rept. No. LMSC-HREC-TR-867333-IV, NASA-CR-171002, 53 pp (Dec 1983)

N84-20638

Key Words: Blades, Turbine blades, Space shuttles, Fatigue life

Low pressure fuel turbopump turbine labyrinth seal tip rubbing analysis, gas dynamic analysis, and HPFTP blade crack and blade impact are presented.

BEARINGS

(Also see No. 2600)

84-2458

Effects of Bearing Deadbands on Bearing Loads and Rotor Stability

Control Dynamics Co., Huntsville, AL, Rept. No. NASA-CR-170986, 198 pp (Jan 20, 1984)

N84-19814

Key Words: Bearings, Limit cycle analysis

A generic model of a turbopump, simplified to bring out these effects, is examined. This model demonstrates that

bearing deadbands which are of the same order of magnitude or larger than the center-of-mass offset of a rotor due to mass imbalances cause significantly different dynamic behavior than would be expected of a linear, dynamical system. This fundamentally nonlinear behavior yields altered stability characteristics and altered bearing loading tendencies.

84-2459

Avoiding Misalignment Problems in Filament-Wound Bearings

J.H. Cooper, Jr.

Garlock Bearings, Inc., Thorofare, NJ, Mach Des., 56 (6), pp 69-74 (Mar 22, 1984) 6 figs

Key Words: Bearings, Alignment

Filament-wound bearings in heavily loaded joints sometimes crack unexpectedly at the edges. The fractures usually can be traced to misalignment that concentrates loads at one end of the bearing. To predict such failures contact pressure computations, based on empirical misalignment data, are presented.

84-2460

Contributions to Dynamics Study of Air-Lubricated Gas Bearings at High Compressibility Numbers

T. Chikazawa

Ph.D. Thesis, Columbia Univ., 177 pp (1983) DA8406483

Key Words: Bearings, Gas bearings, Slider bearings, Computer storage devices

The research concerns transient dynamics of gas lubricated slider bearings operating at very high compressibility numbers. The problem is representative of advanced design concepts of flying head in rotating-disk magnetic memory storage devices. A new computational methodology, based on a convective coordinate system, has been developed to treat the gas lubrication theory for the stated conditions. An opto-electronic motion sensing system was demonstrated for the acquisition of corresponding experimental data. Qualitatively consistent correlation between computed results and experimental data was realized.

84-2461

The Active Magnetic Bearing Enables Optimum Damping of Flexible Rotor

H. Habermann and M. Brunet

Societe de Mecanique Magnetique, France, ASME Paper No. 84-GT-117

Key Words: Rotors, Flexible rotors, Active damping, Magnetic bearings

The active magnetic bearing brings a revolution in the field of suspension of rotating machinery mainly by canceling the needs for lubricating systems, and its unique capabilities of shaft dynamic control of flexible rotors. It allows achievement of very accurate positioning of the shaft, cancels the vibrations due to unbalance, crosses the shaft bending frequency, and overcomes the problems due to gyroscopic effects.

84-2462

A Study on EHD Squeeze Films Between Spherical Planes under Periodic Motion

K. Ikeuchi, H. Mori, S. Ichi, T. Yamazaki, and T. Ohkubo

Kyoto Univ., Kyoto, 606, Japan, Bull. JSME, 27 (226), pp 809-814 (Apr 1984) 17 figs, 10 refs

Key Words: Squeeze-film bearings, Lubrication, Periodic excitation

Squeeze films between spherical elastic surfaces lubricated by incompressible lubricant under sinusoidal normal motion are numerically analyzed and the effects of the curvature and the squeeze number on the floating height of the thruster, the minimum film thickness and the energy dissipation are investigated. A squeeze film bearing of silicon rubber lubricated by mineral oil is vibrated, and the film pressure and the displacement of the thruster are measured to confirm the theory.

GEARS

84-2463

Effect of Coupled Torsional-Flexural Vibration of a Geared Shaft System on the Dynamic Tooth Load

S.V. Neriya, R.B. Bhat, and T.S. Sankar

Concordia Univ., Montreal, Quebec, Canada H3G 1M8, Shock Vib. Bull, No. 54, Pt. 3, pp 67-75 (June 1984) 9 figs, 2 tables, 3 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shafts, Gear teeth, Torsional vibrations, Flexural vibration, Unbalanced mass response, Geometric effects

The dynamic load on gear teeth is studied considering the coupling between the flexural and torsional vibrations in a simple geared shaft system. The flexibility of the mating teeth and the driving and driven shafts are included in the analysis. The coupled equations of motion for the geared shaft system are developed along with a constraint equation which ensures contact between the two mating teeth. The free vibration problem is solved to obtain the natural frequencies and mode shapes.

COUPLINGS

84-2464

Improvement of Dynamic Properties of Shafts for Free Elastic Ring Couplings

B. Spruogis and A. Jakstas

Vilnius Civil Engrg. Inst., Vilnius, Lithuanian SSR, Problems in Theor. and Appl. Mechanics, 26th Proc. in Mechanics, Vilnius Civil Engrg. Inst., Lithuanian SSR, 1984, pp 141-148, 2 figs, 3 refs

Key Words: Couplings, Rings, Shafts, Vibration isolation

The article deals with ten modifications of coupling circuit design in terms of a free elastic ring. Such couplings have better depreciation, vibration isolation and compensation properties as well as common design. Sumptions are presented for the analysis of the couplings and test conditions of the elastic ring breaking strength.

FASTENERS

(Also see Nos. 2557, 2603)

84-2465

Misalignment Ills Cured with CV Joints

G.L. Myers

Con-Vel Plant, Dana Corp., Detroit, MI, Power Transm. Des., 26 (5), pp 27-30 (May 1984) 6 figs, 3 tables

Key Words: Joints (junctions), Alignment

The use of constant velocity U-joints for transmitting power by means of shafts experiencing misalignment angles of up to 35°, without introducing torsional vibrations, is described.

84-2466

The Development of a Method for the Shock-Resistant Securing of Large Batteries in Submarines

A. Jansen

Royal Netherlands Navy, The Hague, Shock Vib. Bull., No. 54, Pt. 2, pp 29-41 (June 1984) 25 figs, 1 table, 6 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Joints (junctions), Adhesives, Shipboard equipment response, Submarines, Underwater explosions

The paper describes the different tests carried out for the development of an adhesive material (polyurethane) for bonding a hook-construction to the deck and the battery, to prevent the upwards movement of large batteries in a submarine during an underwater explosion. Test results are presented and discussed.

84-2467

Analysis of Fatigue Failure Mechanics of Bolted Joints

V. Kaganas

Vilnius Civil Engrg. Inst., Vilnius, Lithuanian SSR, Problems in Theor. Appl. Mechanics, 26th Proc. in Mechanics, Vilnius Civil Engrg. Inst., Lithuanian SSR, 1984, pp 157-167, 5 figs, 9 refs

Key Words: Joints (junctions), Bolted joints, Fatigue life, Crack propagation

The initiation and propagation of fatigue cracks in bolted joints are under consideration. The trajectories of propagation of such cracks are described as well. The stresses intensity coefficients K_I and K_{II} are proposed in order to describe the failure process of bolted joints.

84-2468

Estimation of Constructional Strength of Bolted Joints and Means to Increase It

V. Kaganas and A. Speicys

Vilnius Civil Engrg. Inst., Vilnius, Lithuanian SSR, Dynamics and Strength of Machinery and Structures, Collection of Articles in Mechanics No. 25, Vilnius Civil Engrg. Inst., Vilnius, Lithuanian SSR, 1983, pp 155-165, 1 fig, 8 refs

(In Russian)

Key Words: Joints (junctions), Bolted joints, Cyclic loading, Fatigue life

Cyclic failure and its dependence upon manufacturing as well as loading conditions of bolted joints are described. The conditions for the initiation of brittle and ductile failures are presented. It was found that surface hardening and the use of composite pins prolong the fatigue life of medium strength bolted joints.

VALVES

84-2469

Aerodynamic Study on Noise and Vibration Generated in High Pressure Gas Valves. Part 3: Noise and Vibration Induced by Internal Oscillating Flows in Conical Plug - Circular Chest Valves

M. Nakano and K. Tajima

Yamagata Univ., 4-3-16, Jonan, Yonezawa, Yamagata, 992, Japan, Bull. JSME, 27 (226), pp 691-699 (Apr 1984) 15 figs, 7 refs

Key Words: Valves, Noise generation, Vibration generation

Some effects of valve chest on noise and vibrations generated in a test valve are investigated experimentally and theoretically in close relation to flow patterns of internal supersonic air flow and acoustic modes in the valve chest. The test valve consists of a conical plug, a plane seat and a circular chest, and high pressure air is discharged into the atmosphere through the valve. The experimental pressure ratio is less than twenty.

STRUCTURAL COMPONENTS

STRINGS AND ROPES

84-2470

The Nonlinear Free Vibration of a Damped Elastic String

C. Gough

Dept. of Physics, Univ. of Birmingham, Birmingham, UK, J. Acoust. Soc. Amer., 75 (6), pp 1770-1776 (June 1984) 8 figs, 8 refs

Key Words: Strings, Damped structures, Elastic properties, Free vibration

A theoretical analysis of the large-amplitude free vibration of a damped elastic string shows that the perturbation in vibrational frequency and the precession of any orbital motion of the string about its equilibrium position resulting from nonlinearity is simply related to the mean-square radius and area of the orbital motion.

84-2471

Vibrating Strings with Obstacles (Cordes vibrantes avec obstacles)

H. Cabannes

Laboratoire de Mecanique Theorique, associe au C.N.R.S. Université Pierre et Marie Curie, 4 place Jussieu, 75230 Paris Cedes 05, Acustica, 55 (1), pp 14-20 (Apr 1984) 5 figs, 15 refs

(In French)

Key Words: Strings, Vibration analysis

The principal results relating to the movements of a vibrating string in the presence of a field object, a rectilinear object or a pointed object are reviewed. Sufficient conditions are given for the movement to be an almost periodic function of time, and certain properties of the motion are fixed.

CABLES

84-2472

Parametric Analysis of Large Amplitude Free Vibrations of a Suspended Cable

G. Rega, F. Vestroni, and F. Benedettini

Istituto di Scienza delle Costruzioni, Universita dell'Aquila 67100, L'Aquila, Italy, Intl. J. Solids Struc., 20 (2), pp 95-105 (1984) 9 figs, 2 tables, 13 refs

Key Words: Cables, Large amplitudes, Free vibration

Partial differential equations of motion suitable to study moderately large free oscillations of an elastic suspended cable are obtained. An integral procedure is used to eliminate the spatial dependence and to reduce the problem to one ordinary differential equation which shows quadratic and cubic nonlinearities. The frequency-amplitude relationship for symmetric and antisymmetric vibration modes is studied

and a numerical investigation is performed to describe the nonlinear phenomenon in a large range of values of the cable sag-to-span ratio.

84-2473

Aeroelastic Stability of Suspension Catenary

R. Sofronie

Dept. of Civil Engrg., Bucharest, Rev. Roumaine Sci. Tech., Mecanique Appl., 28 (5), pp 533-555 (1983) 15 figs, 4 tables, 7 refs

Key Words: Cables, Catenaries, Suspended structures, Transportation vehicles, Aerodynamic loads

The paper deals with an electric railway line recently built in a plain area which, under strong winds, develops large movements disturbing traffic. In order to establish the causes of these railway events, the oscillations induced by the running pentograph were first studied. Then the aeroelastic phenomena developed under laminar and turbulent flow of the wind were considered. The influence of ice loading on aeroelastic phenomena was further taken into account.

84-2474

Small-Amplitude Vibrations of Extensible Cables

B. Shih and I.G. Tadjbakhsh

Rensselaer Polytechnic Inst., Troy, NY, ASCE J. Engrg. Mech., 110 (4), pp 469-576 (Apr 1984) 10 figs, 8 refs

Key Words: Cables, Free vibration, Small amplitudes, Galerkin method

Equations governing small-amplitude free vibrations of extensible cables are determined. The resulting eigenvalue problem is solved using the Galerkin procedure. Numerical results agree with previous results in the inextensible limit and provide useful extension to extensibility for a wide range of geometrical and material parameters.

84-2475

Ground Shock Effect on Soil Field Inclusions

R.E. McClellan

The Aerospace Corp., El Segundo, CA, Shock Vib. Bull., No. 54, Pt. 2, pp 203-208 (June 1984) 2 figs, 2 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Cables, Underground structures, Hardened installations, Ground shock

The displacement response of a high density inclusion to ground shock is different from that of the surrounding soil field. An expression for inclusion-soil field peak relative displacement is derived in terms of the soil, inclusion, and ground shock parameters of interest. The magnitude of peak relative displacement is examined using reasonable values of soil and inclusion parameters, and for ground shock strengths commensurate with hardened design against nuclear weapons effects.

84-2476

Cross-Rope Transmission Tower-Line Dynamic Analysis

L. Kempner, Jr. and S. Smith

Bonneville Power Admn., P.O. Box 3621, Portland, OR 97208, ASCE J. Struc. Engrg., 110 (6), pp 1321-1334 (June 1984) 14 figs, 2 tables, 5 refs

Key Words: Transmission lines, Cables

An investigation of the dynamic behavior of a cross-rope-suspension system electrical transmission line structure is presented. Experimental and theoretical studies, which include both modal and forced-response analyses, is performed. An analysis of the techniques employed and a comparison of results is included.

BARS AND RODS

84-2477

Non-Linear Longitudinal Waves in Bars

S.K. Malik and M. Singh

Simon Fraser Univ., Burnaby, B.C. V5A 1S6, Canada, Intl. J. Nonlin. Mech., 19 (3), pp 187-194 (1984) 2 figs, 13 refs

Key Words: Bars, Wave propagation, Longitudinal waves

The finite amplitude longitudinal waves along a uniform bar are examined by using the method of multiple scales. The evolution of the complex amplitude of a quasi-monochro-

matic progressive wave is shown to be governed by a nonlinear Schrödinger equation. The analysis reveals that the constant amplitude progressive waves are stable against modulation.

84-2478

Rotary and Longitudinal Oscillations of a Bar Rotating and Sliding in the Motionlesstube Sliding

V. Paliunas
Kaunas Polytechnic Inst., Kaunas, Lithuanian SSR,
Problems in Theor. and Appl. Mechanics, 26th Proc. in Mechanics, Vilnius Civil Engrg. Inst., Lithuanian SSR, 1984, pp 5-18, 4 figs, 2 refs

Key Words: Bars, Tubes, Concentric structures

The axis of the underformed elastic bar is assumed to be parallel to that of the tube, the bar being pressed to the inner surface of the tube and uniformly rotating about its longitudinal axis and at the same time sliding along the tube. In such a case the differential equation describes the rotary and longitudinal oscillations of a bar.

84-2479

Behavior of an Elastic Rod Falling into a Vibrating Circular Cylinder

Y. Shinohara, M. Asukai, and T. Shimogo
Keio Univ., 14-1, Hiyoshi 3-chome, Kohoku-ku Yokohama 223, Japan,
Bull. JSME, 27 (226), pp 794-801 (Apr 1984) 10 figs, 3 refs

Key Words: Rods, Nuclear reactor components, Seismic response

An elastic rod falling into a vibrating circular cylinder is a model of a control rod falling into a thimble of PWR nuclear reactor core under an earthquake excitation. In this paper, the dynamical behavior of the rod is clarified by taking collision and friction between the rod and the thimble into consideration, and time required for the rod to fall into the thimble is estimated by a simplified analytical model, which is based on the results of a computer simulation. The influences of input acceleration, input frequency, and coefficient of friction upon the falling time of the rod are examined.

BEAMS

(Also see Nos. 2437, 2489, 2490)

84-2480

Transverse Vibrations of Beams with Variable Moment of Inertia and an Intermediate Support

S. Alvarez and P.A.A. Laura
Inst. of Applied Mechanics, Puerto Belgrano Naval Base, Argentina,
Appl. Acoust., 17 (4), pp 255-260 (1984) 1 fig, 1 table, 5 refs

Key Words: Beams, Flexural vibration, Variable material properties

The above problem is tackled using the Ritz method and approximating the deflection function by means of polynomial co-ordinate functions which satisfy the essential boundary conditions. The presence of an axial force and concentrated masses is considered. Fundamental frequency coefficients are determined in the case of a rather complex structure taking into account different types of boundary conditions.

84-2481

Flexural Vibration of a Simply Supported Beam under the Action of a Moving Body with a Pendulum

M. Yoshizawa, K. Kawahara, and Y. Tsujioka
Keito Univ., 3-14-1 Hiyoshi, Kohoku-ku, Yokohama, Japan,
Bull. JSME, 27 (226), pp 779-785 (Apr 1984) 7 figs, 7 refs

Key Words: Beams, Flexural vibration, Moving loads

This report deals with flexural vibration of a simply supported beam, along which a body with a pendulum moves slowly at constant velocity. The governing equations of the whole system, which are simultaneous nonlinear ordinary differential equations with slowly varying coefficients, are asymptotically solved by using the method of multiple scales. An approximate expression for the deflection of the beam is obtained in the nonresonant case and the maximum deflection is estimated in the internal resonant case.

84-2482

Traveling Waves in Beam on Elastic Foundation

M.C. Wang, A. Badie, and N. Davids
Pennsylvania State Univ., University Park, PA 16802,

ASCE J. Engrg. Mech., 110 (6), pp 879-893 (June 1984) 17 figs, 23 refs

Key Words: Beams, Elastic foundations, Moving loads, Railroad tracks

The dynamic response of an infinitely long beam on elastic foundation was analyzed by the method of direct analysis. The conditions analyzed included a step sustained loading with two values of spring constant in the foundation, and rectangular pulse loadings with seven pulse durations. The results of the analysis for the sustained loading agreed very well with an available solution.

84-2483

Dynamic Non-Linear Response of Beams Subjected to Impact Loads

C.N. DeSilva and H.Y. Chen

Wayne State Univ., Detroit, MI 48202, J. Sound Vib., 93 (4), pp 489-502 (Apr 22, 1984) 2 figs, 14 refs

Key Words: Beams, Impact excitation

A nonlinear theory is presented for plane deformation of beams which allows for longitudinal stretching as well as for cross-sectional stretching and shearing. The exact strain measures for this theory are also deduced. The longitudinal and flexural motions are coupled in the theory.

84-2484

Further Developments in Determining the Dynamic Contact Law

J.F. Doyle

Purdue Univ., West Lafayette, IN 47907, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 579-583, 5 figs, 3 refs

Key Words: Beams, Impact force, Force measurement, Frequency domain method, Transverse shear deformation effects

A force/strain relation (incorporating shear effects) for the impact of beams is established in the frequency domain. Inversion by use of a fast Fourier transform algorithm is shown to allow the force history to be determined. The effects of sampling rate and size are considered when analyzing experimental data.

84-2485

Experimental Investigation of Vibroimpact of Two Cantilever Beams

C.N. Bapat and S. Sankar

Concordia Univ., Montreal, Quebec, Canada, Shock Vib. Bull., No. 54, Pt. 2, pp 165-175 (June 1984) 15 figs, 1 table, 9 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Vibro-impact systems, Beams, Cantilever beams, Free vibration, Forced vibration, Experimental data

The damping effect of collisions occurring at only one point along the length between two cantilever beams in free and forced vibrations were experimentally investigated. The use of a snubber made from neoprene pad instead of a steel stud at the impact location had little effect on the free vibrations. In forced vibrations with one sided clearance, displacement amplitudes were reduced considerably when the resonant frequencies of beams differed.

84-2486

Determination of Shear Coefficient of a General Beam Cross Section by Finite Element Method

C.M. Friedrich and S.C. Lin

Westinghouse Electric Corp., Bettis Atomic Power Lab., West Mifflin, PA, Shock Vib. Bull., No. 54, Pt. 3, pp 51-58 (June 1984) 6 figs, 3 tables, 6 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Beams, Shear strengths, Warping, Finite element technique

A finite element method is formulated to determine the distribution of warping deflections of a general cross section of a beam under a shear load. Formulae for the shear stresses, shear strains, shear stiffness, and shear coefficient are obtained in terms of the warping deflections. Numerical values of the shear stresses and shear coefficients are computed for four beam cross sections and compared with values obtained by other writers or by approximate solutions.

84-2487

Quantitative Assessment of Mass Discretization in Structural Dynamic Modelling

K.M. Vashi

Westinghouse Electric Corp., Pittsburgh, PA, ASME Paper No. 84-PVP-29

Key Words: Beams, Bars, Vibration analysis

This paper presents a quantitative assessment of mass discretization by utilizing exact analytical solution to the discrete problem of beam and bar vibrations. The assessment examines the effect of mass discretization on the accuracy of natural frequencies, modes, and participation factors.

84-2488

Vortex Shedding Induced Dynamic Response of Marine Risers

F. Rajabi, M.F. Zedan, and A. Mangiavacchi

Brown & Root, Inc., Houston, TX 77001, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 214-221 (June 1984) 13 figs, 28 refs

Key Words: Marine risers, Wave forces, Vortex-induced excitation, Vortex shedding, Beams, Modal superposition method, Frequency domain method

An analytical model to predict the dynamic response of a riser in regular waves or in current to vortex shedding-induced lift forces is described. The riser is treated as a continuous beam under tension. A modal superposition scheme is used to solve the linearized equation of motion in the frequency domain. The excitation lift force is represented by a harmonic function with a frequency equal to the dominant vortex shedding frequency.

CYLINDERS

(Also see No. 2511)

84-2489

The Nonlinear Dynamics of Long, Slender Cylinders

Y.C. Kim and M.S. Triantafyllou

Dept. of Ocean Engrg., Cambridge, MA 02139, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 250-256 (June 1984) 7 figs, 13 refs

Key Words: Cylinders, Beams, Nonlinear theories, Marine risers

The nonlinear dynamics of long, slender cylinders for moderately large deformations are studied by projecting the solution along the set of eigenmodes of the linear problem. The resulting set of nonlinear ordinary differential equations is truncated on the basis of bandlimited response. The efficiency of the method is due to the derivation of asymptotic solutions for the linear problem in its general form, by using the WKB method. Applications for the dynamics of risers, including the effects of nonlinear fluid drag and geometric nonlinearity demonstrate the features of the method.

COLUMNS

84-2490

Eigenvalues for Beam-Columns on Elastic Supports

H.H. West and M. Mafi

Pennsylvania State Univ., University Park, PA 16802, ASCE J. Struc. Engrg., 110 (6), pp 1305-1320 (June 1984) 11 figs, 11 refs

Key Words: Columns, Beam-columns, Elastic supports, Eigenvalue problems, Natural frequencies, Dynamic buckling

The eigenvalues associated with beam-columns, which rest on elastic supports, are determined by an initial-value numerical method. These eigenvalues can be related to the buckling loads, critical foundation constants, or natural frequencies of vibration. Interrelationships between these eigenvalues are examined and three-way dimensionless critical diagrams display the results of this study for single-span structures with various boundary conditions and for multi-span structures. These show that, for the cases presented, the square of the natural frequency varies linearly with respect to both the axial load and the elastic support constant.

FRAMES AND ARCHES

84-2491

Optimal Forms of Shallow Arches with Respect to Vibration and Stability

R.H. Plaut and N. Olhoff

The Technical Univ. of Denmark, Lyngby, Denmark, J. Struc. Mech., 11 (1), pp 81-100 (1983) 2 figs, 4 tables, 8 refs

Key Words: Arches, Optimization, Fundamental frequency, Snap through problems

Shallow, linearly elastic arches of unspecified form but with given uniform cross section and material, are considered. For

given span and length of the arch, two different optimization problems are formulated and solved. In the first, we determine the form of the arch which maximizes the fundamental vibration frequency. The corresponding vibration mode turns out to be either symmetric or antisymmetric. In the second, a static load with given spatial distribution is considered, and the critical value of the load magnitude for snap-through instability is maximized.

MEMBRANES, FILMS, AND WEBS

84-2492
Free Vibration of a Point-Supported Membrane Stretched by Inextensible Strings
T. Irie, G. Yamada, and Y. Kobayashi
Hokkaido Univ., Sapporo, 060 Japan, J. Sound Vib., 93 (4), pp 513-522 (Apr 22, 1984) 4 figs, 3 tables, 22 refs

Key Words: Membranes (structural members), Natural frequencies, Mode shapes, Ritz method

An analysis is presented for the free vibration of a point-supported rectangular membrane with uniform tension stretched by inextensible strings along the edges. The membrane is transformed into a square membrane of unit length by a transformation of variables. The transverse deflection of the square membrane is expressed in a series of the products of the deflection functions of strings parallel to the edges, and the frequency equation is derived by the Ritz method.

PLATES
(Also see No. 2622)

84-2493
Real Time Vibration Control of Rotating Circular Plates by Temperature Control and System Identification
C.D. Mote, Jr. and A. Rahimi
Univ. of California, Berkeley, CA 94720, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 123-128 (June 1984) 10 figs, 4 tables, 11 refs

Key Words: Plates, Flexural vibration, Vibration control, Real time technique, Temperature effects

A system for real-time control of the transverse vibration of a rotating circular plate, based on a thermal stressing technique and dynamic system identification, is presented. In this method the natural frequency spectrum of the plate is modified through the purposeful introduction of thermal membrane stresses. Evaluations with computer simulations and experimental measurments on a thin circular plate verify the system capability to suppress transverse vibration in a changing thermal environment.

84-2494
Fatigue Strength of Retrofitted Cover Plates
A.H. Sahli, P. Albrecht, and D.W. Vannoy
Univ. of Maryland, College Park, MD 20742, ASCE J. Struc. Engrg., 110 (6), pp 1374-1388 (June 1984) 9 figs, 3 tables, 13 refs

Key Words: Plates, Fatigue life, Bolted joints

The fatigue strength of cover plate ends, retrofitted with splice plates and high strength bolts in friction, was determined experimentally. The flanges at the cover plate ends were noncracked, half precracked, or fully precracked prior to retrofitting. The first condition applies to rehabilitation, the others to repair of cover plated girders.

84-2495
Symmetric Nonlinear Response of a Circular Plate Due to Heat Flux at $z = +h/2$
C. Massalas, A. Dalamangas, and A. Leonditsis
Univ. of Ioannina, Greece, Rev. Roumaine Sci. Tech., Mecanique Appl., 28 (6), pp 643-650 (1983) 2 figs, 1 table, 5 refs

Key Words: Plates, Circular plates, Temperature effects

The influence of a constant heat flux on the static and dynamic response of simply supported and clamped circular plate with edge immovably constrained is investigated.

84-2496
Nonlinear Vibration of a Plate in an Ultrasonic Flow (Nichtlineare Schwingung Einer Platte In Einer Überschallstromung)
Nguyen-Xuan-Hung
Polytechnic Inst. Hanoi Vietnam, Rev. Roumaine Sci. Tech., Mecanique Appl. 28 (6), pp 615-622 (1983) 5 figs, 5 refs
(In German)

Key Words: Plates, Shear vibration, Fluid-induced excitation, Ultrasonic vibration

Shear vibration of a plate in gas flow at a near critical velocity under alternating loads is investigated, taking into consideration the nonlinearity of the plate.

84-2497

Natural Response of Non-Rigidly Connected Rectangular Plates

M.N. Pavlovic and O.B. Tardy

Imperial College of Science and Tech. London SW7 2AZ, UK, Engrg. Struc., 6 (2), pp 90-96 (Apr 1984) 5 figs, 1 table, 21 refs

Key Words: Plates, Rectangular plates, Welded joints, Flexural vibration

The effect of a finite rotational restraint along two opposite edges of a rectangular plate is investigated for a range of mode numbers, aspect ratios and joint stiffnesses. Some practical applications are discussed by reference to welded joints. The extension of the theory to plate assemblies is briefly discussed.

84-2498

Impact Strength of Steel Plates Struck by Projectiles (Effect of Mechanical Properties on Critical Fracture Energy)

H. Yoshizawa, S. Ohte, Y. Kashima, N. Chiba and S. Shida

Toshiba R and D Center, Toshiba Corp., Ukishima-cho 4-1, Kawasaki-shi, Japan, Bull. JSME, 27 (226), pp 639-644 (Apr 1984) 9 figs, 5 tables, 10 refs

Key Words: Impact tests, Plates, Steel, Fracture properties

In order to determine the strength of structures which are required to be leak-tight when struck by projectile, a series of impact tests for steel plates were carried out, and an evaluation formula to estimate the critical fracture energy of SGV49 steel plate for SUS304 projectile was derived. A series of additional tests for steel plates and projectiles of different materials were carried out to investigate the effect of each material on the critical fracture energy.

84-2499

Flexural Free Vibrations of Rectangular Plates with Complex Support Conditions

S.C. Fan and Y.K. Cheung

Halcrow Asia Partnership, Hong Kong, J. Sound Vib., 93 (1), pp 81-94 (Mar 8, 1984) 2 figs, 5 tables, 24 refs

Key Words: Plates, Rectangular plates, Flexural vibration, Finite strip method

The spline finite strip method of analysis is introduced and applied to the study of flexural free vibration response of thin rectangular plates with complex support conditions. Examples are given to demonstrate the versatility, accuracy and efficiency of the method.

84-2500

The Receptance Method Applied to the Free Vibration of Continuous Rectangular Plates

S. Azimi, J.F. Hamilton, and W. Soedel

Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 93 (1), pp 9-29 (Mar 8, 1984) 5 figs, 2 tables, 29 refs

Key Words: Plates, Rectangular plates, Free vibration, Mobility method

Vibrational characteristics of thin rectangular plates continuous over intermediate rigid simple supports and simply supported along two opposite edges with simply supported and/or clamped end conditions were calculated using the receptance method. Three different procedures were illustrated, one of which is an exact solution.

84-2501

Free Vibration of Continuous Polar Orthotropic Annular and Circular Plates

Y. Narita

Computer Center, Hokkaido Inst. of Tech., Sapporo 061-24, Japan, J. Sound Vib., 93 (4), pp 503-511 (Apr 22, 1984) 3 figs, 5 tables, 15 refs

Key Words: Plates, Natural frequencies, Ritz method

The free vibration of a polar orthotropic annular plate supported on concentric circles is analyzed by the Ritz method with use of Lagrange multipliers. A trial function

for the deflection of the plate is expressed in terms of simple power series, and a frequency equation for the plate is derived by the condition for minimizing the total potential energy with the constraint equations included. In the numerical examples it is also shown that the method can directly yield quite accurate frequency values for a solid circular plate.

SHELLS

84-2502
Vibration and Damping Analysis of a Multilayered Cylindrical Shell, Part II: Numerical Results

N. Alam and N.T. Asnani

Aligarh Muslim Univ., Aligarh, India, AIAA J., 22 (7), pp 975-981 (July 1984) 18 figs, 1 ref

Key Words: Shells, Cylindrical shells, Layered materials, Resonant frequencies, Computer programs

The solution for the vibration and damping analysis of a general multilayered cylindrical shell consisting of an arbitrary number of orthotropic material elastic and viscoelastic layers with simply supported end conditions was reported in Part I. The solution has been programmed on an IBM 360 computer for evaluating the resonant frequency parameters and the associated system loss factors for all families of modes having nonaxisymmetric and axisymmetric vibrations of the general multilayered shell. The resonating frequency parameters and associated system loss factors and their variations with geometrical and material parameters for three-, five-, and seven-layered shells with alternate elastic and viscoelastic layers are reported.

84-2503
A Flugge-Type Theory for the Analysis of Anisotropic Laminated Non-Circular Cylindrical Shells

K.P Soldatos

Dept. of Mechanics, Univ. of Ioannina, Greece, Intl. J. Solids Struc., 20 (2) pp 107-120 (1984) 5 figs, 4 tables, 24 refs

Key Words: Shells, Cylindrical shells, Layered materials, Equations of motion, Flugges shell theory

For a generally anisotropic laminated thin elastic noncircular cylindrical shell, subjected to a combined loading, the equations of motion of a second approximation Flugge-type theory are derived and expressed in terms of the shell middle-surface displacement components. As an application, for the free vibration problem of a cross-ply laminated non-circular cylindrical shell subjected to S2 simply supported edge boundary conditions, these equations are solved by employing the method of Galerkin.

84-2504
Finite Element Random Response Analysis of Cooling Tower

T.Y. Yang and R.K. Kapania

Purdue Univ., West Lafayette, IN, ASCE J. Engrg. Mech., 110 (4), pp 589-609 (Apr 1984) 10 figs, 3 tables, 42 refs

Key Words: Shells, Towers, Cooling towers, Random response, Finite element technique

A finite element formulation and Gaussian quadrature procedure, using both the direct complex matrix inversion and the modal superposition methods, are presented for studying the stationary random response of shell structures, such as a cooling tower. The random distributed loads are assumed as stationary in time but can be nonhomogeneous in space. A 48 d.o.f. quadrilateral shell element with bi-cubic Hermitian polynomial interpolation functions as displacement shape functions is adopted.

84-2505
Vibration of Shell of Revolution (Improved Theory)

S. Takahashi, K. Suzuki, and T. Kosawada

Yamagata Univ., Yonezawa, Japan, Bull. JSME, 27 (226), pp 786-793 (Apr 1984) 8 figs, 2 tables, 11 refs

Key Words: Shells of revolution, Vibration analysis

Vibration of shell of revolution is studied by improved theory. The meridian of the middle surface is a concave circular arc. Under the assumptions of displacements and stresses proposed by Mirsky, the equations of vibration and the boundary conditions are introduced.

84-2506
Dynamic Response of Shells Containing Fluid

F.L. DiMaggio

Columbia Univ., New York, NY 10027, Shock Vib. Dig., 16 (6), pp 3-9 (June 1984) 47 refs

Key Words: Shells, Fluid-filled containers, Sloshing, Fluid-induced excitation, Reviews

This is a survey of papers and reports, most of which were written during the past three years, concerned with the vibrations of deformable shells containing a fluid. Work involving only sloshing effects or including flow-induced vibration is not considered.

84-2507

Behavior of Pressurized Cylinders with Multiple Internal Cracks

J F. Throop and R.R. Fujczak
U.S. Army Armament, Munitions, and Chemical Command, Armament Res. and Dev. Ctr, Large Caliber Weapon Systems Lab., Benet Weapons Lab., Watervliet, NY 12189, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 590-598, 20 figs, 5 refs

Key Words: Shells, Cylindrical shells, Pressure vessels, Fatigue life, Cracked media

Thick-walled cylinders containing more than one internal crack are compared with one containing a single crack. Their crack growth and strain behavior show that one of the cracks becomes dominant and controls the failure. Monitoring the circumferential strain over the dominant crack gives an indication of when failure is imminent.

84-2508

Direct Energy Minimization Approach to Whipping Analysis of Pressure Hulls

K.A. Bannister
Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, Shock Vib. Bull., No. 54, Pt. 2, pp 67-85 (June 1984) 16 figs, 10 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shells, Cylindrical shells, Pressure vessels, Whipping phenomena, Submarines

The large deformation behavior of cylindrical shells executing low frequency, but large amplitude, whipping-type vibrations is addressed. This problem is important in the practical design of cylindrical shell structures to resist failure due to in-service bending loads combined with pressure. Submarine pressure hulls, aircraft fuselages, and industrial piping applications fall into this category of structure/loading combination. A new methodology is described for dealing with such nonlinear shell analysis problems.

84-2509

Response of a Pre-Stressed, Orthotropic Thick Cylindrical Shell Subjected to a Pressure Pulse

S. Chonan
Univ. of British Columbia, 2324 Main Mall, Vancouver, Canada, J. Sound Vib., 93 (1), pp 31-38 (Mar 8, 1984) 4 figs, 8 refs

Key Words: Shells, Cylindrical shells, Pulse excitation, Transverse shear deformation effects, Rotatory inertia effects, Longitudinal inertia effects

The dynamic response of an axially stressed, orthotropic cylindrical shell subjected to a step pressure pulse at its interior wall is investigated. The solution is obtained on the basis of a thick shell theory in which the effects of shear deformation and of rotatory and longitudinal inertias are retained. The dynamic coefficient is calculated for several values of the thickness-to-length ratio and the radius-to-length ratio of shell and is shown graphically as a function of the axial stress parameter and the orthotropy coefficient of the shell.

PIPES AND TUBES

84-2510

Heat Exchanger Tube Vibrations. 1976 - April, 1984 (Citations from the Energy Data Base)

NTIS, Springfield, IL, 70 pp (May 1984)
PB84-865187

Key Words: Tube arrays, Heat exchangers, Vibration analysis, Bibliographies

This bibliography contains 86 citations concerning design, fabrication, and testing of heat exchanger tubes and tube bundles for vibrational considerations. Basic excitation mechanisms of tube vibrations, effects of heat exchanger configurations, preoperational testing of tubes, and vibration detection techniques are discussed. Mathematical models and computer simulation techniques are presented.

84-2511

Vortex-Induced Vibrations of a Flexible Cylinder Near a Plane Boundary Exposed to Steady and Wave-Induced Currents

D.T. Tsahalis

Shell Development Co., Houston, TX 77001, J. Energy Resources Tech., Trans ASME, 106 (2), pp 206-213 (June 1984) 9 figs, 14 refs

Key Words: Cylinders, Pipelines, Underwater pipelines, Vortex-induced vibration, Model testing

Model tests were carried out in a wave tank to determine the effect of combined steady and wave-induced currents and/or the proximity of a plane boundary (seabottom) on the vortex-induced vibrations of a flexible pipe. The response of the center of the pipe span was measured using a biaxial accelerometer. The results show that the proximity of the plane boundary and/or superposition of waves on the steady flow have a pronounced effect on the amplitude and frequency response in both the transverse and in-line directions.

84-2512

Analytical and Experimental Investigation of Flow-Reversible Heat Exchangers Using Temperature-Entropy Bond Graphs

R. Shoureshi and K.M. McLaughlin

Purdue Univ., West Lafayette, IN 47907, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 170-175 (June 1984) 12 figs, 2 tables, 16 refs

Key Words: Heat exchangers, Fluid-induced excitation, Temperature effects, Bond graph technique

Modeling of heat exchangers using true bond graphs with temperature and rate of change of entropy as power variables is presented. Techniques used for modeling of irreversibilities and compressible flows are shown. The results of two and three lump models are compared with experimental results, with the agreement between those low order models and the experimental results being good.

84-2513

Seismic Design Technology for Breeder Reactor Structures. Volume 4. Special Topics in Piping and Equipment

D.P. Reddy

Agbabian Associates, El Segundo, CA, Rept. No. DOE/SF/01011-T25-V.4, 215 pp (Apr 1983)
DE84004811

Key Words: Nuclear reactor components, Piping systems, Seismic design

This volume is divided into five chapters: experimental verification of piping systems, analytical verification of piping restraint systems, seismic analysis techniques for piping systems with multisupport input, development of floor spectra from input response spectra, and seismic analysis procedures for in-core components.

84-2514

Measurement of Structure-Borne Sound Energy Flow Along Pipes. Part 3: Analysis of Systematic and Random Errors

J.W. Verheij and C.J.M. Vanruiten

Technisch Physische Dienst TNO-TH, Delft, The Netherlands, Rept. No. TPD-308.785/1, TDCK-77849, 46 pp (Apr 8, 1983)
N84-22377

Key Words: Pipes (tubes), Structure-borne noise, Sound measurement, Error analysis

Errors in methods based on finite difference approximations and using cross spectral densities of accelerations at closely spaced pipe cross sections for measuring structure-borne energy flow in thin walled circular cylindrical pipes (by separating the contributions of longitudinal torsional and bending waves) are analyzed. A quantity called direct field ratio, that defines the ratio between the measured energy flow and the energy flow that would be measured in a free propagating wave under noise-free conditions, is introduced. It indicates conditions where the estimates of the cross spectral density are sensitive to several error sources.

84-2515

Wall Effects on Sound Propagation in Tubes

N.W. Page and D.J. Mee

Univ. of Queensland, St. Lucia, Australia 4067, J. Sound Vib., 93 (4), pp 473-480 (Apr 22, 1984) 2 figs, 3 tables, 9 refs

Key Words: Tubes, Sound waves, Wave propagation

Numerical solutions have been obtained for the exact equations describing the propagation of periodic axisymmetric waves in a rigid cylindrical tube.

DUCTS

84-2516

Propagation and Radiation of Sound from Flanged Circular Ducts with Circumferentially Varying Wall Admittances. I: Semi-Infinite Ducts

C.R. Fuller

NASA Langley Res. Ctr., Hampton, VA 23665, J. Sound Vib., 93 (3), pp 321-340 (Apr 8, 1984) 11 figs, 17 refs

Key Words: Ducts, Sound waves, Wave propagation

The propagation of acoustic waves in an infinite circular duct with a circumferentially varying wall admittance is theoretically considered. An exact solution is obtained and used to investigate the characteristics of wave dispersion, mode shapes and admittance. The scattering from a flanged termination of the circular duct is then analyzed with use of a rigorous solution in oblate spheroidal co-ordinates. The effects of the asymmetry of the duct wall admittance on the amplitude reflection coefficients, radiated power transmission losses and the far field radiation directivity patterns are examined.

84-2517

Propagation and Radiation of Sound from Flanged Circular Ducts with Circumferentially Varying Wall Admittances. II: Finite Ducts with Sources

C.R. Fuller

NASA Langley Res. Ctr., Hampton, VA 23665, J. Sound Vib., 93 (3), pp 341-351 (Apr 8, 1984) 5 figs, 10 refs

Key Words: Ducts, Sound waves, Wave propagation

The radiation of sound from a flanged duct system containing various hard-walled pressure sources and a finite length of non-uniformly lined duct is considered. Reflection coefficients, transmission losses and the directivity of the radiated field are evaluated. Direct comparisons between the results for the non-uniformly lined ducts, a uniformly lined duct and a hard-walled duct are made for fixed values of admittance, liner length and source distributions.

84-2518

Propagation and Radiation of Sound in a Finite Length Duct

K.S. Wang and T.C. Tszeng

National Tsing Hua Univ., Hsinchu, Taiwan, Rep. of China, J. Sound Vib., 93 (1), pp 57-59 (Mar 8, 1984) 19 figs, 19 refs

Key Words: Ducts, Sound waves, Wave radiation, Wave propagation

An analysis has been carried out to investigate sound transmission in an unflanged circular duct of finite length. A new formulation for calculating the generalized radiation impedance of the opening of a finite length duct with a spinning source inside is presented. The effect of interference between the duct apertures at its two ends is identified in the calculations of radiation impedance, reflection coefficient, and the far field radiation pattern.

BUILDING COMPONENTS

(Also see No. 2538)

84-2519

A Linear Mathematical Model for the Seismic Inplane Behaviour of Brick Masonry Walls. Part 1: Theoretical Considerations

Y. Mengi, H. Sucuoglu, and H.D. McNiven

Cukurova Univ., Adana, Turkey, Earthquake Engrg. Struc. Dynam., 12 (3), pp 313-326 (May/June 1984) 12 refs

Key Words: Walls, Masonry, Seismic response, Mathematical models

Two mathematical models are presented for the linear dynamic behavior of masonry walls. The study is completed in three stages: experimental observations, selection of a mathematical model and the determination of model parameters through optimization analysis. The theoretical analysis used in the development of the mathematical models is presented.

84-2520

A Linear Mathematical Model for the Seismic Inplane Behaviour of Brick Masonry Walls. Part 2: Determination of Model Parameters through Optimization Using Experimental Data

H. Sucuoglu, Y. Mengi, and H.D. McNiven

Univ. of California, Berkeley, CA, Earthquake Engrg. Struc. Dynam., 12 (3), pp 327-346 (May/June 1984) 15 figs, 3 tables, 13 refs

Key Words: Walls, Masonry, Seismic response, Optimization

The parameters appearing in the mixture and effective modulus models proposed in Part 1 are determined through optimization by matching theoretical and experimental responses. The optimization analysis is performed in frequency space. The response quantities chosen to be matched are the complex frequency response functions (experimental and theoretical) relating the Fourier transforms of top and base accelerations of the wall. Computations in optimization analysis are carried out by introducing an object (error) function and minimizing it using the Gauss-Newton method.

84-2521

Behaviour of Fixed Cantilever Walls Subject to Lateral Shaking

M.D. Bolton and R.S. Steedman

Cambridge Univ., UK, Rept. No. CUED/D-SOILS/TR-148, 16 pp (1984)

PB84-170158

Key Words: Walls, Seismic tests

The relatively clean base shaking produced by the Bumpy Road actuator, and the previous leaf-spring shaker of Morris described in an earlier paper, has produced dynamic data which can be followed point-by-point and instant-by-instant. Data of displacements, accelerations, and bending moments have been shown to be capable of straightforward correlation. The prospects for an approximate, quasi-static, analysis of retaining walls which respects elasticity on rebound, and the friction and dilation of soil at failure, are promising.

84-2522

Wind Direction and Structural Reliability: II

Yi-Kwei Wen

Univ. of Illinois, Urbana, IL 61801, ASCE J. Struc. Engrg., 110 (6), pp 1253-1264 (June 1984) 13 figs, 4 tables, 9 refs

Key Words: Structural members, Wind-induced excitation

Wind data from weather bureau airport stations are used to verify previous analytical results of the effect of wind direction on structural reliability. The feasibility of theoretical prediction of long-term direction effects based on short-term data is also investigated.

84-2523

Improved Modeling of Tubular Brace Elements under Severe Cyclic Loading

G.H. Powell, D.G. Row, and J.P. Hollings

Univ. of California, Berkeley, CA 94720, J. Energy Resources Tech., Trans. ASME, 106 (2), pp 240-245 (June 1984) 8 figs, 7 refs

Key Words: Structural members, Tubes, Steel, Off-shore structures Drilling platforms, Cyclic loading

Theory and examples are presented for a new structural element suitable for modeling tubular steel braces in offshore platforms. Yielding, buckling and postbuckling strength losses are considered using a simplified, yet essentially rational, theory.

ELECTRIC COMPONENTS

CONTROLS

(Switches, Circuit Breakers)

84-2524

The Generalized Response of Servovalve-Controlled, Single-Rod, Linear Actuators and the Influence of Transmission Line Dynamics

J. Watton

University College, Cardiff, UK, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 157-162 (June 1984) 7 figs, 28 refs

Key Words: Actuators, Frequency response

The open-loop response of servovalve-controlled single-rod linear actuators is investigated for both the extending and retracting cases. A linearized frequency response technique is used to establish the probable type of dynamic behavior. Nondimensional results are presented as an aid to system design, and a boundary is established such that a simplified approximation may be used. A particular class of system is then examined where interconnecting transmission lines would be important, and the techniques previously used are modified accordingly.

GENERATORS

84-2525

Some Methods of Transient Analysis of Asynchronous Generators as Wind Generators

S. von Zweygbergk, K.E. Hallenius, O. Carlson, and J. Hylander

Naemnden foer Energiproduktionsforskning, Stockholm, Sweden, Rept. No. NE-VIND-83-12, 45 pp (Dec 1982)

DE84750107

(In Swedish)

Key Words: Generators, Transient analysis

The following models of analysis are presented: analysis by special vectors, analysis of a fixed three-phase stator and a fixed two-phase rotor, analysis of a three-phase stator and a three-phase rotating rotor (two modes), and analysis of a fixed three-phase stator and a fixed three-phase rotor.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

84-2526

Model Studies of Barrier Performance in the Presence of Ground Surfaces. Part I - Thin, Perfectly Reflecting Barriers

D.A. Hutchins, H.W. Jones, and L.T. Russell

Queen's Univ., Kingston, Ontario, Canada K7L 3N6, J. Acoust. Soc. Amer., 75 (6), pp 1807-1816 (June 1984) 13 figs, 26 refs

Key Words: Noise barriers

A scale model study is presented of the performance of thin, perfectly reflecting semi-infinite barriers in the presence of both asphalt and grass-covered surfaces. The barrier insertion loss is shown to be strongly dependent on the type of ground on either side of the barrier. Observed behavior is explained by a study of the interference phenomena occurring in both the barrier's presence and its absence.

84-2527

Model Studies of Barrier Performance in the Presence of Ground Surfaces. Part II - Difference Shapes

D.A. Hutchins, H.W. Jones, and L.T. Russell

Queen's Univ., Kingston, Ontario, Canada K7L 3N6, J. Acoust. Soc. Amer., 75 (6), pp 1817-1826 (June 1984) 24 figs, 24 refs

Key Words: Noise barriers

Modeling experiments are reported which have investigated the frequency dependence of barrier insertion loss for various noise barrier designs. The effect of ground surfaces has been studied, treating both grass-covered ground and asphalt. Results show that interference effects are an important feature of observed behavior.

84-2528

Environmental Acoustic Quality in Jeddah Urban Sites

K.A. Elshorbagy

FMES, King Abdulaziz Univ., P.O. Box 9034, Jeddah (21413), Saudia Arabia, Appl. Acoust., 17 (4), pp 261-274 (1984) 4 figs, 5 tables, 10 refs

Key Words: Urban noise, Traffic noise

Surveys of physical exposure to noise at urban sites in Jeddah city indicate that noise from road traffic is very intensive. Relatively high instant sound levels (90 dB(A) and higher) were recorded on a number of congested, as well as freely-flowing traffic, roads. The results of this research demonstrate the necessity for the application of a traffic noise control program on Jeddah main roads and also the need for attention to be paid to the indoor acoustic quality of homes and offices.

84-2529

Seismo-Acoustic Effects of Sonic Booms on Archeological Sites, Valentine Military Operations Area

J.C. Battis

Air Force Geophysics Lab., Hanscom AFB, MA, Rept. No. AFGL-TR-83-0304, AFGL-ERP-858, 37 pp (Nov 9, 1983)

AD-A139 581

Key Words: Sonic boom, Damage prediction

Seismo-acoustic recordings of sonic booms were made at two sites in the Valentine Military Operations Area (MOA).

Each location was selected as representative of a class of significant archeological sites found within the MOA. These studies indicate that sonic booms are unlikely to cause damage to the archeological finds.

84-2530

Air Intake Silencer and Filter for the BMW 524 td (Ansauggeräuschdämpfer und Luftfilter für den BMW 524 td)

H.H. Melzer and W. Brox

Galgenbachweg 15, D-8056, Neufahrn, MTZ Motortech. Z., 45 (5), pp 223-227 (May 1984) 8 figs, 3 refs (In German)

Key Words: Engine mufflers, Noise reduction, Diesel engines, Design techniques

During the development of the BMW diesel engine it was found necessary to design a new air intake silencer because of the special requirements of the diesel engine. The filters used on the BMW gasoline engines were found to be unsuitable. Compared to gasoline engines, the diesel engine has a distinctly higher rate of air flow. Limited space for the accommodation of an adequately large air filter made a careful silencer layout necessary to provide optimum filter dimensions and a favorable configuration for the filter housing.

84-2531

A Practical Prediction Method for the Stochastic Insulation Effect of a Sound Barrier with Arbitrary Random Noise Excitation

M. Ohta, S. Yamaguchi, and E. Uchino

Faculty of Engrg., Hiroshima Univ., Saijo, Higashi-Hiroshima, 724, Japan, Appl. Acoust., 17 (4), pp 291-301 (1984) 6 figs, 1 table, 4 refs

Key Words: Noise barriers, Prediction techniques

A sound barrier is often used as a typical noise control device to modify sound propagation characteristics. Also, statistical parameters such as the median value of sound level, L_x, as well as the lower order statistical values of sound energy or level, are important for noise evaluation and regulation problems. A new trial of statistical prediction for the stochastic insulation effect of a sound barrier is proposed in a special case where the insulation system parameters have to be improved, especially from a methodological viewpoint.

84-2532

Acoustic Wave Propagation through Shear Layer of the German-Dutch Open Jet Wind Tunnel (DNW)

R. Ross, K.J. Young, R.M. Allen, and J.C.A. Vanditschuizen

National Aerospace Lab., Amsterdam, The Netherlands, Rept. No. NLR-MP-83003-U, 14 pp (Jan 14, 1983) (Pres. at the 8th AIAA Aero-Acoustic Conf., Atlanta, Apr 11-13, 1983)

N84-22379

Key Words: Sound waves, Wave propagation, Wind tunnel testing

The acoustic correction procedures for 1/3 octave analysis in a 20 m long open jet, surrounded by a large anechoic room, were checked with a calibrated noise source using noise data taken inside and outside the flow. Multitone marine horns and an acoustic driver coupled to a horn for broadband and single tone noise were used.

84-2533

Generation of Acoustic Waves by an Impulsive Point Source in a Fluid/Solid Configuration with a Plane Boundary

A.T. deHoop and J.H.M.T. van der Hijden

Dept. of Electrical Engrg., Lab. of Electromagnetic Res., Delft Univ. of Tech., P.O. Box 5031, 2600 GA Delft, The Netherlands, J. Acoust. Soc. Amer., 75 (6), pp 1709-1715 (June 1984) 5 figs, 2 tables, 13 refs

Key Words: Sound waves, Wave generation, Point source excitation

The space-time acoustic wave motion generated by an impulsive monopole point source in a fluid/solid configuration with a plane boundary is calculated with the aid of the modified Cagniard technique. The source is located in the fluid, and numerical results are presented for the reflected-wave acoustic pressure, especially in those regions of space where head-wave contributions occur.

84-2534

Long-Range Pacific Acoustic Multipath Identification

J. Northrop and R.C. Shockley

Naval Ocean Systems Ctr., San Diego, CA 92152, J. Acoust. Soc. Amer., 75 (6), pp 1760-1765 (June 1984) 10 figs, 1 table, 7 refs

Key Words: Underwater sound, Sound waves, Wave propagation

Acoustic signals from three long-range (500-700 km) transmission paths in the Northeast Pacific were examined for multipath structures. Sound propagation along each path encountered both different sound-speed provinces and unique bathymetry which, together with the range differences, caused characteristic pulse arrival patterns at each hydrophone site. Ray-path arrivals were modeled using IMPULSE, a new ray-theoretical impulse response code.

84-2535

Acoustic Radiation Pressure in the Near Field

K. Beissner

Physikalisch-Technische Bundesanstalt, Braunschweig Germany, J. Sound Vib., 93 (4), pp 537-548 (Apr 22, 1984) 4 figs, 7 refs

Key Words: Sound waves, Wave radiation

Langevin's acoustic radiation pressure on an absorbing target has been stated in numerous plane wave theories as being given by twice the kinetic acoustic energy density, by the total acoustic energy density or by acoustic intensity divided by the speed of sound. In a non-plane wave these three quantitites are no longer equal to one another. An expression for the radiation pressure in a three-dimensional sound field is derived from the literature. Although including the plane wave result as a special application, it is not in general equal to any of the three quantities mentioned, but is something different, the numerical values of which are discussed for the sound field of a continuously vibrating, circular piston source.

SHOCK EXCITATION

(Also see No. 2629)

84-2536

A Computational Procedure for Peak Instructure Motions and Shock Spectra for Conventional Weapons

S.A. Kiger, J.P. Balsara, and J.T. Baylot

USAE Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180, Shock Vib. Bull. No. 54, Pt. 2, pp 223-226 (June 1984) 4 figs, 5 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Weapons effects, Structural response, Acceleration analysis, Velocity, Displacement analysis

A semiempirical procedure for computing maximum values of structural displacement, velocity, and acceleration is presented. The simplified methods take into account the large attenuation of the conventional weapon shock front as it traverses the structure, by using an integrated average value of corresponding free-field motions. Instructure motions are predicted by modifying these average free-field motions based on data collected in conventional weapons tests over the past several years. Computed peak instructure motions are then amplified to estimate the instructure shock spectra.

84-2537

Penetration of Short Duration Airblast into Protective Structures

J.R. Britt and J.L. Drake

Applied Res. Associates, Southern Div., Vicksburg, MS, Shock Vib. Bull. No. 54, Pt. 2, pp 209-221 (June 1984) 13 figs, 17 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA, Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Hardened installations, Protective shelters, Shock waves, Wave propagation, Rooms, Explosion effects

This paper describes a combined analytical and experimental effort to study blast wave propagation into the interior of rooms from short duration airblast produced by conventional weapons detonated near entrances to these facilities. Twenty-seven small-scale high-explosive tests were conducted to study the effects of opening size, incident blast pulse duration and peak pressure levels on the blast transmitted into structures. Two structures with square openings were used in the program.

84-2538

Preliminary Design Criteria and Certification Test Specifications for Blast Resistant Windows

G.E. Meyers, W.A. Keenan, and N.F. Shoemaker

Naval Civil Engrg. Lab., Port Hueneme, CA, Shock Vib. Bull. No. 54, Pt. 2, pp 227-255 (June 1984) 17 figs, 3 tables, 18 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Windows, Blast resistant structures, Testing techniques, Specifications

Preliminary design criteria for blast resistant windows exposed to blast overpressures up to 25 psi are recommended. Design procedures and design curves for fully tempered glass are presented and parametized according to glass thickness, glass dimensions, glass aspect ratio, peak blast overpressures and effective blast duration. Curves for annealed glass are also presented for the purpose of analyzing the safety of existing structures. Design criteria for frames and a test certification procedure are also discussed.

84-2539

A Study of the Effect of Mass Loading on the Shock Environment

Qi-Zheng Wang and Hua-Bao Lin

Bejing Inst. of Strength and Environment Engrg., Bejing, China, Shock Vib. Bull. No. 54, Pt. 2, pp 183-191 (June 1984) 18 figs, 2 tables, 8 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Pyrotechnic shock environment, Shock tests

The weight variations in mounted subassemblies have relatively little effect on the pyrotechnic shock environment at the mounting point. This is the so-called mass loading effect. This paper presents a mechanical model which attempts to explain theoretically the mechanism of the mass loading effect. A drop test and a structural striking test are conducted to simulate the pyrotechnic shock.

84-2540

Models for Shock Damage to Marine Structural Materials

D.W. Nicholson

Naval Surface Weapons Ctr., White Oak, MD 20910, Shock Vib. Bull. No., 54, Pt. 2, pp 177-182 (June 1984) 2 figs, 10 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Materials, Shock response, Strain rate, Constitutive equations

Various types of strain rate embrittlement thought to occur in marine structural materials under shock loading are discussed. A constitutive model is briefly sketched which illustrates how material flow and damage are measured, their thresholds, how they compete to dissipate available elastic and kinetic energy, and conditions under which their governing processes become unstable.

84-2541

Low Velocity, Explosively Driven Flyer Plate Design for Impact Fuze Development Testing

R.A. Benham

Sandia National Lab., Albuquerque, NM, Shock Vib. Bull., No. 54, Pt. 2, pp 155-164 (June 1984) 8 figs, 1 table, 10 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Testing techniques, Warheads, Explosives, Fuzes (ordnance)

A new design of an explosive system to propel a thick, aluminum flyer plate into a reentry vehicle warhead contact fuze system has been designed and tested. This design produces a reverse ballistic impact environment used to study the function of contact sensors at impact velocities of around 1525 mps (5000 fps). The paper presents the explosive design, calculations of shock wave damage to the flyer plate, and results of an experiment in which this design was utilized.

84-2542

Holographic Study of Dynamic Surface Response to Explosive Loading

W.H. Wilson, D.C. Holloway, and De-Sen Shao

Univ. of Maryland, College Park, MD 20742, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 555-564, 11 figs, 13 refs

Key Words: Holographic techniques, Interferometric techniques, Explosion effects, Blast loads, Ground vibration

Surface and near-surface disturbances propagating in the earth from blasting sites were investigated through high speed holographic interferometry. Three dimensional models made of Hydrostone (a cast gypsum) were impulsively loaded by detonating PETN contained in canisters attached to the model surface.

84-2543
Nonlinear FSI Due to Underwater Explosions
J.E. Jackson, Jr. and M.A. Jamnia
Clemson Univ., Clemson, SC 29631, ASCE J. Engrg. Mech. 110 (4), pp 507-517 (Apr 1984) 11 figs, 1 table, 22 refs

Key Words: Interaction: structure-fluid, Underwater explosions, Shock waves, Wave propagation

A method of solution for the transient response of nonlinear fluid-structure systems is presented. Finite element discretization is applied to the nonlinear hydrodynamic equations describing water. Performance of five equations of state describing water in the presence of strong shocks are compared for the case of shocks propagating underwater and reflecting from a rigid wall.

84-2544
Blast Loading of Closures for Use on Shelters - II
G.A. Coulter
Ballistic Res. Lab., Army Armament Res. and Dev. Ctr., Aberdeen Proving Ground, MD, Rept. No. ARBRL-MR-03338, SBI-AD-F300 397, 58 pp (Feb 1984)
AD-A139 632

Key Words: Closures, Protective shelters, Blast resistant structures, Failure analysis

Results are presented for the blast loading of expedient closures intended for use in the key worker shelter pressure range. Failure levels were determined for long duration blast loads from the BRL 2.44 m simulator. Loading data and high speed photographs describe the failure modes.

84-2545
Shock-Induced Dynamic Stall
L.E. Ericsson and J.P. Reding
Lockheed Missiles & Space Co., Inc., Sunnyvale, CA, J. Aircraft, 21 (5), pp 316-321 (May 1984) 12 figs, 24 refs

Key Words: Airfoils, Stalling, Shock response

At freestream Mach numbers above M = 0.3 shock/boundary-layer interaction begins to complicate the unsteady airfoil stall characteristics. The present paper shows how theoretical relationships can be developed for the interdependence between unsteady and steady characteristics to provide the means whereby the shock-induced dynamic stall characteristics can be determined if the static characteristics are known; e.g., from experiments.

84-2546
Progressive Failure for Seismic Reliability Analysis
F. Casciati and L. Faravelli
Univ. of Pavia, Pavia, Italy, Engrg. Struc., 6 (2), pp 97-103 (Apr 1984) 5 figs, 2 tables, 16 refs

Key Words: Seismic response, Computer programs, Reliability

Progressive failure of structural systems subject to seismic excitations is investigated. The system survives the first rupture of an element section (brittle failure) and failure occurs when a predetermined state of excessive displacement is achieved. This study is developed in probabilistic terms and may be seen as part of a simplified approach to seismic reliability analysis whose formulation is in progress. In particular, previous research is systematized and improved on from a mechanical point of view.

84-2547
Influence of Gravity Forces in the Response of Framed Structures to Earthquake Excitations
G. Oliveto
Istituto di Scienza delle Costruzioni, Universita di Catania, Viale A. Doria 6, 95100 Catania, Italy, Engrg. Struc., 6 (2), pp 104-112 (Apr 1984) 11 figs, 12 refs

Key Words: Framed structures, Seismic response

An algorithm is presented which accounts for the instability effects of gravity forces in the dynamic analyses of plane frameworks with uniform members subject to earthquake excitations. A nonlinear static analysis, the formulation of a *stress dependent stiffness matrix and the solution of a non*linear eigenvalue problem are the basic steps of the algorithm. Numerical results are provided to show the effects of gravity forces on the frequencies and modes of vibration of tall frameworks and on their response to earthquake excitations.

84-2548

Stochastic Seismic Analysis of Multidegree of Freedom Systems

M. Di Paola, M. Ioppolo, and G. Muscolino

Istituto di Scienza delle Costruzioni, Facolta di Ingegneria, Universita di Palermo, Vialle delle Scienze, 90128 Palermo, Italy, Engrg. Struc., 6 (2), pp 113-118 (Apr 1984) 8 figs, 1 table, 19 refs

Key Words: Seismic analysis, Multidegree of freedom systems

An unconditionally stable step-by-step procedure is proposed to evaluate the mean square response of a linear system with several degrees of freedom, subjected to earthquake ground motion. A nonstationary modulated random process, obtained as the product of a deterministic time envelope function and a stationary noise, is used to simulate earthquake acceleration. The accuracy of the procedure and its extension to nonlinear systems are discussed. Numerical examples are given for a hysteretic system, a duffing oscillator and a linear system with several degrees of freedom.

84-2549

Dynamic Response of Transversely Impacted Beams of Different Materials

D. Goldar and M. Paldas

Delhi College of Engrg., Delhi-110 006, India, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 584-589, 3 figs, 2 tables, 3 refs

Key Words: Impact response, Materials, Beams

Experimental results of peak-tensile stress for simply supported beams of mildsteel, aluminium, PMMA, araldite and urethane rubber subjected to low velocity impact for same beam-striker weight ratio have been compared with the intensities of initial stress pulses, which indicate interesting correspondence with the Poisson's ratios for these materials.

VIBRATION EXCITATION

(Also see Nos. 2587, 2588)

84-2550

Modelling of an Airfoil Empirical Flow Field Below and through Dynamic Stall

D. Favier, C. Maresca, and J. Rebont

Institut de Mecanique des Fluides, L.A. 03 du C.N.R.S., 1, rue Honnorat, 13003 Marseille, France, J. de Mecanique Theor. Appl., 3 (1), pp 15-39 (1984) 14 figs, 29 refs

Key Words: Airfoils, Stalling

A potential theory with additional concentrated vorticity influences has been applied to the incompressible flowfield around a NACA 0012 airfoil in plunging motion below and through dynamic stall. For oscillations of incidence below static stall, a potential flow model with additional contribution of a vortex sheet in the airfoil wake is developed. A convenient recursion relation for the wake integral function is provided.

84-2551

Windamper Method of Galloping Control. Pt. II. Prediction of Dynamic Galloping. Final Report

A.S. Richardson, Jr.

Res. Consulting Associates, Lexington, MA, Rept. No. DOE/CE/15102-T1-Pt 2, 51 pp (Oct 15, 1983) DE84003290

Key Words: Galloping, Aerodynamic loads, Ice

A technical review and extension of the Windamper methodology for controlling galloping (ice buildup on windward side) is presented. The new material consists of three main parts: review and analysis of single conductor by coupled two-degree-of-freedom analysis, extension of that method to the bundled conductor, and a report of the new Windamper aerodynamic data.

84-2552

Aerodynamic Response of Airfoils in Sinusoidal Oblique Gust

T. Nagashima and Y. Tanida

Univ. of Tokyo, Tokyo, Japan, J. Aircraft, 21 (5), pp 302-308 (May 1984) 8 figs, 14 refs

Key Words: Airfoils, Aerodynamic loads, Wind-induced excitation

A linearized theory has been developed to provide check results for advancing numerical calculations of unsteady lift and moment of airfoils in subsonic sinusoidal oblique gusts. The airfoils are thin, flat plates of infinite span and may be in cascade. The gust response curves for varying flow

Mach number and spanwise gust wave number are presented. The obliqueness of the gust wave front with respect to the airfoil leading edge is found to be very influential upon the aerodynamic lift and moment.

84-2553
The Orthogonality Property and the Coincidence of Eigenvalue Spectrums of Mechanical Systems with Different Boundary Conditions
V.G. Chudnovsky
423 W. 120th St., New York, NY 10027, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 401-405, 3 refs

Key Words: Natural frequencies, Boundary condition effects

The conditions under which a given mechanical system has the same spectrum of free frequencies under different boundary conditions are determined.

84-2554
Effect of Air Cavity on the Vibration Analysis of Loaded Drums
S. De
National Res. Inst., P.O. Bankisol, Bankura, W. Bengal, India, Shock Vib. Bull., No. 54, Pt. 3, pp 143-154 (June 1984) 2 figs, 4 tables, 26 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Musical instruments, Vibration analysis, Cavity effect

This paper is concerned with the free vibration analysis of loaded circular and annular drums with an enclosed air cavity. The effect of the compressibility of the entrapped air on the vibration characteristics is studied.

84-2555
Natural Vibrations of Elastic Structures Completely or Partially Submerged in Liquid
V. Kargaudas
Kaunas Polytechnic Inst., Kaunas, Lithuanian SSR, Problems in Theor. and Appl. Mechanics, 26th Proc. in Mechanics, Vilnius Civil Engrg. Inst., Lithuanian SSR, 1984, pp 19-36, 2 figs, 2 tables, 14 refs
(In Russian)

Key Words: Submerged structures, Natural frequencies, Mode shapes, Boundary value problems

The boundary-value problem of vibrations of the linear system is called invariant if the proportions of its natural frequencies and natural forms are constant when the system rigidity is uniformly changed. It is proved that a mechanic system is invariant in vacuum and remains invariant after full or partial submersion in a perfect liquid.

MECHANICAL PROPERTIES

DAMPING

(Also see Nos. 2373, 2383, 2425, 2438, 2461)

84-2556
Oscillations of Immiscible Liquids in a Rectangular Container: A New Damper for Excited Structures
H.F. Bauer
Hochschule der Bundeswehr, 8014 Neubiberg, Germany, J. Sound Vib., 93 (1), pp 117-133 (Mar 8, 1984) 5 figs, 27 refs

Key Words: Dampers, Wind-induced excitation

Structural systems are quite susceptible to oscillations induced by winds. There exists no effective means to reduce or even dampen the dangerous motion of the structure. A new damping device is suggested consisting of a liquid container filled with two immiscible liquids, in which the motion of the interface is able to dampen the structure effectively. For this reason the necessary liquid theory is derived, with which a mathematical mechanical model is presented. The effectiveness of the system for a cantilever beam is shown.

84-2557
Stochastic Dynamic Analysis of a Structure with Frictional Joints
Qian-Li Tian, Yu-Bio Liu, and Da-Kang Liu

Inst. of Mechanics, Chinese Academy of Sciences, Shock Vib. Bull., No. 54, Pt. 3, pp 11-17 (June 1984) 2 figs, 1 table, 6 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Joints (junctions), Coulomb friction, Viscous damping, Structural modification techniques

Since about 90% of the damping in a structure is originated from the joints, an efficient method to reduce the vibration level of a structure is to increase the damping in these joints. A stochastic-dynamic-analysis is presented for a structure with frictional joints. It is assumed that the structure is excited by a stationary stochastic process with Gaussian distribution and the statistical linearization is made to transform the frictional forces to equivalent viscous damping forces. A localized damping modification method is used to calculate its response spectrum and corresponding statistical characteristics.

84-2558

The Analysis by the Lumped Parameter Method of Blade Platform Friction Dampers Used in the High Pressure Fuel Turbopump of the Space Shuttle Main Engine

R.J. Dominic

Univ. of Dayton Res. Inst., Dayton, OH, Shock Vib. Bull., No. 54, Pt. 3, pp 89-98 (June 1984) 14 figs, 7 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Dampers, Vibration dampers, Blades, Spacecraft components, Turbojet engines

Premature cracking of the first stage turbine blades in the high pressure fuel turbopump of the space shuttle main engine could be alleviated by redesign of the platform friction dampers that are used to reduce the vibration response of the blades. Analytical studies, by the lumped mass method, of friction damper effectiveness have been performed. Methodologies used in the program are described.

FATIGUE

(Also see Nos. 2447, 2507)

84-2559

Advanced Reliability Method for Fatigue Analysis

Yih-Tsuen Wu and P.H. Wirsching

Univ. of Arizona, Tucson, AZ 85721, ASCE J. Engrg. Mech., 110 (4), pp 536-553 (Apr 1984) 9 figs, 5 tables, 15 refs

Key Words: Fatigue life, Reliability

When design factors are considered as random variables and the failure condition cannot be expressed by a closed form algebraic inequality, computations of risk (or probability of failure) may become extremely difficult or very inefficient. This study suggests using a simple and easily constructed second degree polynomial to approximate the complicated limit state in the neighborhood of the design point; a computer analysis relates the design variables at selected points. A fast probability integration technique can then be used to estimate risk. The capability of the proposed method is demonstrated in an example of a low cycle fatigue problem for which a computer analysis is required to perform local strain analysis to relate the design variables.

84-2560

Life Prediction in Low Cycle Fatigue Using Elastic Analysis

J. Tortel, P. Petrequin, and R. Roche

CEA Centre d'Etudes Nucleaires de Saclay, Gif-sur-Yvette, France, Rept. No. CEA-CONF-6692, CONF-8304141-1, 19 pp (Apr 1983) (ASME Intl. Conf. on *Advances in Life Prediction Methods*, Albany, NY, Apr 18, 1983)

DE84750265

Key Words: Fatigue life, Prediction techniques, Elastic analysis

A brief review of the methods proposed in open literature and in construction codes is presented. A comprehensive mechanical analysis shows that inelastic behavior leads to a magnification of elastically computed strain. This magnification is strongly related to the mechanical behavior of the component.

ELASTICITY AND PLASTICITY

84-2561

Wave Propagation Parallel to the Layers in Elastic or Viscoelastic Layered Composites

Ming-Zhi Hu and T.C.T. Ting

Univ. of Illinois at Chicago, Chicago, IL 60680, J. Struc. Mech., 11 (1), pp 13-35 (1983) 8 figs, 7 refs

Key Words: Layered materials, Wave propagation, Viscoelastic properties, Elastic properties

Transient waves propagating parallel to the layers in a linear elastic or viscoelastic layered composite are studied. A step load in time is applied at the boundary x = 0 and the head-of-the-pulse asymptotic solution is obtained for large x and large time t. For viscoelastic composites the interaction between the dissipation and the dispersion is controlled by a parameter γ that contains the material mismatch of the layers and the distance propagated by the waves.

84-2562

A New Second Order Accurate Finite Difference Method for Dynamic Response of Elastic-Plastic Finite Deformation Problems

Hsin-Piao Chen

Ph.D. Thesis, Georgia Inst. of Tech., 219 pp (1983) DA8405593

Key Words: Elastic plastic properties, Finite difference method

A new numerical technique has been developed to analyze the dynamic responses of elastic-plastic solids with finite deformations. The developed numerical scheme is an explicit finite difference scheme with second order accuracy. Since the elastic-plastic finite deformation problem is always path-dependent or time-dependent, the response of this problem is most accurately calculated numerically by a step-by-step incremental analysis. A Cauchy stress and an updated Lagrangian approach are chosen to formulate such a problem.

84-2563

Fracture Mechanics Evaluation of Filament Wound Case Materials Subjected to Operational Environments

H. Bau and S.W. Beckwith

Hercules Aerospace Div., Magna, UT, J. Spacecraft Rockets, 21 (3), pp 281-286 (May/June 1984) 8 figs, 5 tables, 14 refs

Key Words: Fiber composites, Solid propellant rocket engines, Fracture properties

The fracture characteristics of several filament wound composite materials were evaluated over operational conditions typical of solid rocket motor composite cases. The fracture toughness for Mode I crack growth was determined for three composite systems: a Kevlar-49/AS4 graphite laminate and two AS4 graphite laminates of different orientation layup. The fracture toughness and net stress were found to depend on crack length over a fairly large range.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 2619, 2620)

84-2564

Elias Klein Memorial Lecture, Modal Testing - A Critical Review

S. Smith

Lockheed Palo Alto Res. Lab., Palo Alto, CA, Shock Vib. Bull., No. 54, Pt. 1, pp 65-76 (June 1984) 11 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Modal analysis, Experimental modal analysis, Reviews

Modal analysis is characterized by the author as the science for the determination of the dynamic behavior of a structure in terms of its normal modes. The history and state-of-the-art of excitation techniques, measurement of frequency functions, and the analysis of modal properties are briefly reviewed. The author predicts that the new generation of hardware and software will revolutionalize modal testing and analysis.

84-2565

Modal Analysis of Structural Systems Involving Nonlinear Coupling

R.A. Ibrahim, T.D. Woodall, and H. Heo

Texas Tech. Univ., Lubbock, TX 79414, Shock Vib. Bull., No. 54, Pt. 3, pp 19-27 (June 1984) 6 figs, 9 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Modal analysis, Normal modes, Harmonic excitation, Asymptotic approximation

A nonlinear analysis of the interaction of the normal modes of a three degree-of-freedom structure is presented. The asymptotic approximation method, due to Struble, is employed to solve for the structure response under harmonic excitation. Several possible autoparametric resonance conditions are predicted.

84-2566

Experimental Modal Analysis - A Modeling and Design Tool

C.W. deSilva and S.S. Palusamy

Carnegie-Mellon Univ., Pittsburgh, PA, Mech. Engrg., 106 (6), pp 56-65 (June 1984) 12 figs, 1 table

Key Words: Experimental modal analysis

Experimental modal analysis and applications are described. Applications include model development and design refinement of components in flexible manufacturing cells, automobiles, aircraft, cooling towers, missiles, reactor coolant loops, space vehicles, rotating machinery, and digital computer hardware.

84-2567

Quality Control and Sample Comparison Utilizing Differential Modal Analysis (Qualitätskontrolle und Mustervergleich mittels differentieller Modalanalyse)

O. Bschorr and J. Mittmann

Messerschmitt-Bolkow-Blohm GmbH, MBB-Betriebsbereich Ottobrunn, VDI-Z., 126 (9), pp 308-310 (1984) 4 figs, 4 refs

(In German)

Key Words: Modal analysis, Qualification tests

The envisaged final control in series production should serve to check completed individual pieces for dimensional accuracy and the presence of faults. To solve such problems, a system of control under the title of differential modal analysis is proposed. This conception refers to the characteristic measurement frequency of produced pieces, and their comparison with the original. From the proven frequency difference obtained, the number and area of the fault can be determined.

84-2568

A Method of Component Mode Synthesis for Dynamic Analysis

Jao-Hwa Kuang

Ph.D. Thesis, Univ. of Cincinnati, 110 pp (1983) DA8406099

Key Words: Component mode synthesis, Undamped structures

A method of component mode synthesis for determining the dynamic characteristics of an undamped system in a specified frequency band is proposed. The motion of each component is represented by three mode sets: inertia, selected normal and residual modes. Inertia and residual mode sets are introduced to approximate the truncated lower and higher normal modes.

84-2569

On the Effects of Nonlinear Stiffness in Resonance Testing

M. Rades

Polytechnic Inst., Bucharest, Rev. Roumaine Sci. Tech., Mecanique Appl., 28 (6), pp 603-614 (1983) 13 figs, 10 refs

Key Words: Parameter identification technique, Method of harmonic linearization, Jump phenomenon, Resonance tests

The steady-state response of a simple system with a cubic stiffness term in the governing equation of motion is examined using the method of harmonic linearization. The equation of the stability boundary is established for different types of frequency response curves and used to describe the jump phenomena. Two new resonance testing techniques are suggested for the experimental evaluation of the dynamic parameters of structures with nonlinear stiffness.

84-2570

Introduction to the Two-Microphone Cross-Spectral Method of Determining Sound Intensity

M.P. Waser and M.J. Crocker

Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, Noise Control Engrg. J., 22 (3), pp 76-85 (May/June 1984) 14 figs, 25 refs

Key Words: Cross spectral method, Two microphone technique, Sound intensity, Measurement techniques

The intent of this paper is to introduce the reader to the two-microphone sound intensity measurement technique.

This relatively new technique allows one to measure directly the net rate of flow of acoustic energy per unit area. The basic equation employed for the cross-spectral method is derived from well-known fundamental relations. An error analysis is included and some of the classical applications are illustrated.

84-2571

A Spectral Analysis Method for Nonstationary Field Measurements

M.K. Abdelhamid and K.G. McConnell

Iowa State Univ., Ames, IA 50011, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 605-612, 10 figs, 1 table, 8 refs

Key Words: Spectrum analysis, Fatigue life

A method is presented for dealing with the problem of spectral analysis of nonstationary field measurements. The method hypothesizes that the nonstationary signal consists of two stationary signals that belong to different populations (environment and working plus environment) that occur consecutively. The analysis method entails segmenting the time history and estimating the population of each segment. Two estimators are presented and their frequency characteristics are described. Discrete Fourier transforms of zero padded segments are used for estimating the spectral density functions. This method is simply implemented and treats the problem of smoothing the spectral estimates.

84-2572

A Comparison of Intensity and Mean-Square Pressure Methods for Determining Sound Power Using a Nine-Point Microphone Array

D.M. Yeager

IBM Acoustics Lab., P.O. Box 390, Dept. C18, Bldg. 704, Poughkeepsie, NY 12602, Noise Control Engrg. J., 22 (3), pp 86-95 (May/June 1984) 13 figs, 18 refs

Key Words: Measurement techniques, Sound measurement, Sound intensity, Sound power levels, Multi-microphone technique

The measurement of the sound intensity vector using the cross-spectral method is investigated. Calibration procedures are presented and the measured radial intensity of a monopole in a free-field is compared with ideal quantities deduced from mean-square pressure data. The determination of radiated sound power of various sources in a hemi-anechoic environment is compared using both mean-square pressure and intensity methods measured in a nine-point microphone array. The influence of a controlled background noise source on sound power estimates is evaluated and quantified using the concept of apparent sound power.

84-2573

Acoustic Emissions Signature Analysis. Final Report, July 1, 1978 - May 31, 1983

W.J. Pardee and A. Arora

Rockwell International, Thousand Oaks, CA, Rept. No. DOE/ER/02029-T4, 17 pp (Nov 1983) DE84003219

Key Words: Acoustic emission, Signature analysis

A series of systems were studied in an effort to bridge the gap between model sources and practical ones. Measurements were made of acoustic emission from controlled fracture of glass. Results suggested a significant angular dependence.

84-2574

Investigation of Diamond Drilling Equipment Noise by the Sound Intensity Method

G. Krishnappa

Engine Lab., National Res. Council, Ottawa, Ontario, Canada K1A 0R6, Noise Control Engrg. J., 22 (3), pp 112-116 (May/June 1984) 7 figs, 5 refs

Key Words: Sound intensity, Drills, Two-microphone technique

The sources of noise from diamond drilling equipment were investigated by nearfield sound intensity measurements. The two-microphone technique was used to measure sound intensity. Based on the sound power estimates, the engine is the most prominent source of noise. The swivelhead and hoist assembly and the water pump generate almost the same sound power levels, ranking second behind the engine.

84-2575

A Pole-Free Reduced-Order Characteristic Determinant Method for Linear Vibration Analysis Based on Sub-Structuring

B. Dawson and M. Davies

Polytechnic of Central London, London, UK, Shock Vib. Bull., No. 54, Pt. 3, pp 43-50 (June 1984) 3 figs, 3 tables, 4 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA, Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Substructuring methods, Torsional vibrations, Natural frequencies

A general method of solution for the linear vibration analysis of structures is presented. The method is based on substructuring and the formation of a reduced-order characteristic determinant whose zeros yield all the natural vibration frequencies of the system. The concept of the method and its application is illustrated via the determination of the torsional natural frequencies of engine-driven systems involving both discrete and continuous components.

84-2576

Measurement and Analysis of High-Frequency Pressure Oscillations in Solid Rocket Motors

P.M.J. Hughes and E. Cerny

Energy, Mines and Resources Canada, Ottawa, Canada, J. Spacecraft Rockets, 21 (3), pp 261-266 (May/June 1984) 20 figs, 12 refs

Key Words: Solid propellant rocket engines, Vibration measurement, Vibration analysis, Frequency domain method, Time domain method

During the operation of a solid propellant rocket motor, a high-frequency, finite-amplitude pressure oscillation may develop which is superimposed on the large, time-average chamber pressure. A number of novel techniques to isolate the high-frequency pressure signal from the near-D.C. chamber pressure are described. The hardware to do this consists of off-the-shelf instrumentation modified to give the required characteristics. The software package which is used to display and analyze these high frequency signals is also discussed.

84-2577

Analysis of Vibration by Component Mode Synthesis Method (Part 4, Natural Frequency and Natural Mode (II))

M. Ookuma and A. Nagamatsu

Tokyo Inst. of Tech., 12-1, Ohokayama 2-chome, Meguro-ku Tokyo, 152, Japan, Bull. JSME, 27 (225), pp 529-533 (Mar 1984) 8 figs, 8 refs

Key Words: Vibration analysis, Component mode synthesis, Natural frequencies, Mode shapes

A component mode synthesis method is improved for analyzing the vibration of complex structures. The displacements of the interior regions of all components except the interface component are represented with the natural modes of the interface region and the restrained natural modes of these interior regions. The equation of motion of the total structure is translated into a generalized coordinate of these natural modes. Numerical results of the natural frequencies and the natural modes of two specimens are shown.

84-2578

Shock Response Analysis by Personal Computer Using the Extended IFT Algorithm

C.T. Morrow

Encinitas, CA, Shock Vib. Bull., No. 54, Pt. 2, pp 131-141 (June 1984) 21 figs, 5 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Indirect Fourier transform, Fourier transformation, Spectrum analysis, Shock response, Multidegree of freedom systems

This is the third in a series of papers on the development of the Indirect Fourier Transform algorithm for spectral analysis and shock response analysis. The first presented the basic theory and explored computation times and memory requirements. The second reported the development of a program for shock spectral analysis by computer and disclosed that the phase characteristic of the undamped residual shock spectrum could be expressed in terms of an Apparent Starting Time for shock transients. The present paper extends the algorithm to response analysis by computer for single- and multiple-degree-of-freedom systems, with specific mathematical development through two degrees.

84-2579

Study of Vibration Behaviour of a Hydraulic-Turbine

M. Ghosh and A.K. Reddy

Vib. Lab., Bharat Heavy Electricals Limited, Vikasnagar, Hyderabad-500 593, India, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 412-416, 6 figs, 1 table

Key Words: Turbines, Hydraulic turbines, Vibration signatures, Signature analysis

An investigation on the vibration characteristics of a hydroturbine running at 150 rpm is described. Hydraulic turbines are subjected to various types of excitation forces and in this investigation the vibration signature analysis technique is used to study these force characteristics and the response of the turbine. The effect of balancing and excitation of the generator on machine vibration and also its response at various loads are studied in detail. Vibration signatures are given for both renovated and smoothly running units.

84-2580

ESPI -- The Ultimate Holographic Tool for Vibration Analysis?

O.J. Lokberg

Norwegian Inst. of Tech., N-7034 Trondheim - NTH, Norway, J. Acoust. Soc. Amer., 75 (6), pp 1783-1791 (June 1984) 12 figs, 29 refs

Key Words: Vibration analysis, Holographic techniques, Interferometric techniques

Holographic interferometry opened new worlds of research by making possible accurate, global mapping of small dynamic surface displacements in a two-step process. A technique, called Electronic Speckle Pattern Interferometry or ESPI, has been developed in various forms to provide similar results instantly. ESPI's principal capabilities, and some practical applications in industry, biomedicine, and acoustical research are described in an overview in the hope of encouraging its use by researchers who were deterred by the relatively cumbersome process of holography.

84-2581

Dynamic Force Measurement with a Hydraulic Force Balance Valve

T. Vinayagalingam

Dept. of Mech. Engrg., Univ. of West Indies, St. Augustine, Trinidad, West Indies, J. Phys., E: Sci. Instrum., 17 (7), pp 573-576 (July 1984) 5 figs, 3 refs

Key Words: Transducers, Force measurement, Measuring instruments

A hydraulic force balance transducer for measuring force is presented. The useful output is in the form of a pressure signal which could be used directly in hydraulic amplification stages of low-frequency high-power-output servo systems. Typically, the device could be designed to have a capacity of about 20N and a frequency range of operation of 0-30 Hz.

84-2582

Force and Torque Measurement -- A Technology Overview

S.S. Gindy

Eaton Corp. - Lebow, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 765-775, 28 figs, 1 table, 8 refs

Key Words: Force measurement, Measurement techniques, Reviews

Force and torque measurements play a decisive role in the development or improvement of mechanical systems. This paper reviews this role, gives a definition of transduction and explains the concepts utilized in different disciplines of force and torque measurements.

84-2583

Scattering/Diffraction Effects in the Two-Microphone Technique of Measuring Sound Intensity at Sound Incidence Angles Other than 0°

G. Krishnappa

Engine Lab., National Res. Council, Ottawa, Ontario, Canada K1A 0R6, Noise Control Engrg. J., 22 (3), pp 96-102 (May/June 1984) 14 figs, 9 refs

Key Words: Measurement techniques, Sound measurement, Sound intensity, Two microphone technique

Experimental studies were carried out to examine the scattering/diffraction effects from the two microphone probes used to measure sound intensity. Both side-by-side and face-to-face arrangements of the two microphones were examined at angles of incidence of 0 to 75°. Experimental results show that the accuracies of sound intensity measurements are affected by scattering/diffraction of sound at high frequencies and at high angles of incidence.

84-2584

A Microprocessor-Based Laser-Doppler Vibration Probe

A.D. Brown and R.A. Cookson

Cranfield Inst. of Tech., Bedford, UK, ASME Paper No. 84-GT-136

Key Words: Vibration probes, Measuring instruments, Microprocessors (computers)

It is hoped that the development of the microprocessor-based probe described in this paper will lead to a more compact and considerably cheaper instrument and will widen the range of problems for which it was discovered to provide a solution.

84-2585

Comparative Study Between the Sound Intensity Method and the Conventional Two-Room Method to Calculate the Sound Transmission Loss of Wall Constructions

A. Cops and M. Minten
Laboratorium voor Akoestiek en Warmtegeleiding; Dept. Natuurkunde, Katholieke Universiteit Leuven, Heverlee, Belgium, Noise Control Engrg. J., 22 (3), pp 104-111 (May/June 1984) 10 figs, 18 refs

Key Words: Measurement techniques, Sound transmission loss, Walls, Sound intensity

Sound transmission loss measurements were made on different types of wall constructions with a new intensity method. These results were compared with results obtained by using the conventional two-room method. A glass panel, different new types of wall constructions and a special type of partition, used in a round-robin test between different laboratories, were investigated.

84-2586

The Impulse Response of a Focused Source with an Arbitrary Axisymmetric Surface Velocity Distribution

W.A. Verhoef, M.J.T.M. Cloostermans, and J.M. Thijssen
Biophysics Lab. of the Dept. of Opthalmology, Univ. of Nijmegen, 6500 HB Nijmegen, The Netherlands, J. Acoust. Soc. Amer., 75 (6), pp 1716-1721 (June 1984) 6 figs, 14 refs

Key Words: Transducers, Impulse response

An analytical expression for the impulse response of a focused transducer with an axisymmetric nonuniform surface velocity distribution is derived using a finite polynomial expansion of the velocity distribution function. A computing scheme is presented for the numerical calculation of the transient pressure at an observation point in front of the transducer. The effect of various nonuniform velocity distributions on the characteristics of the pressure field of a medium focused transducer is shown with grey-scale pictures of calculated continuous-wave and pulsed pressure distributions.

84-2587

Theoretical and Experimental Study of the Contribution of Radial Modes to the Pulsed Ultrasonic Field Radiated by a Thick Piezoelectric Disk

J.C. Baboux, F. Lakestani, and M. Perdrix
Laboratoire de Traitement du Signal et d'Ultrasons, Institut National des Sciences Appliquees, Batiment 502, 69621 Villeurbanne, France, J. Acoust. Soc. Amer., 75 (6), pp 1722-1731 (June 1984) 10 figs, 33 refs

Key Words: Transducers, Disks, Piezoelectricity, Ultrasonic vibration, Radial vibrations

A theoretical model is presented for evaluating the transient field radiated on the axis of a thick piezoelectric disk, by vibrations propagating radially on the circular transmitting face, from its rim towards its center. A simulation is undertaken to explain the complex changes observed in the amplitude and in the shape of signals when the distance from the disk face varies.

84-2588

The Forward and Backward Projection of Acoustic Fields from Axisymmetric Ultrasonic Radiators Using Impulse Response and Hankel Transform Techniques

A.F. Medeiros and P.R. Stepanishen
Submarine Signal Div., Raytheon Co., Box 360, Portsmouth, RI 02871, J. Acoust. Soc. Amer., 75 (6), pp 1732-1740 (June 1984) 18 figs, 11 refs

Key Words: Transducers, Ultrasonic vibration, Sound waves, Wave radiation, Impulse response, Hankel transformation

A generalized impulse response formulation to evaluate the harmonic pressure field of ultrasonic planar vibrators having axisymmetric nonuniform surface velocity distributions is presented. The harmonic pressure is expressed as a Fourier transform of a generalized impulse response which is a func-

tion of the spatially nonuniform velocity of the vibrator. A backward projection method is then developed to reconstruct the normal surface velocity of axisymmetric vibrators from harmonic field pressures using an angular spectrum or Hankel transform formulation. The numerical accuracy of the backward projection technique is evaluated using the impulse response formulation to evaluate the pressure fields for several velocity distributions on disk vibrators.

84-2589

Effects of Domain Structure on Electrically Excitable Mechanical Resonances in Ferroelectric Ceramics

P.J. Chen

Sandia National Labs., Albuquerque, NM 87185, Intl. J. Solids Struc., 20 (2), pp 121-128 (1984) 4 tables, 7 refs

Key Words: Ceramics, Resonant response

The existence of electrically excitable mechanical resonances in piezoelectric and ferroelectric materials which are not accompanied by any detectable electrical disturbance has been observed. The effects of domain structure on the existence of the mechanical resonances in the ferroelectric ceramic PZT65/35 are examined. It is shown that domain structure affects not only the number of these resonances but also their amplitudes.

DYNAMIC TESTS

(Also see No. 2539)

84-2590

Nondestructive Testing of Plastics. 1972 - April, 1984 (Citations from the International Aerospace Abstracts Data Base)

NTIS, Springfield, VA, 241 pp (May 1984)
PB84-865641

Key Words: Nondestructive tests, Plastics, Bibliographies

This bibliography contains 302 citations concerning techniques and technology for the nondestructive testing or evaluation of various kinds of plastic stock and fabricated plastic products or objects for the detection of flaws or defects which affect their properties and behavior. Special emphasis is placed upon plastics in aerospace applications.

84-2591

Wind Tunnels Applied to Wind Engineering in Japan

R.D. Marshall

National Bureau of Standards, Washington, DC 20234, ASCE J. Struc. Engrg., 110 (6), pp 1203-1221 (June 1984) 5 figs, 3 tables, 6 refs

Key Words: Wind tunnels, Test facilities, Wind-induced excitation

The very substantial investment made in boundary layer wind tunnels over the past two years suggests that Japanese heavy industries and construction corporations see a bright future for wind engineering. It is concluded that a significant penetration of the U.S. market for specialized engineering services is likely to occur within the next few years. The paper presents basic dimensions and performance characteristics for several wind tunnels and four new boundary layer wind tunnels are described in detail.

84-2592

Dynamic Testing of As-Built Civil Engineering Structures -- A Review and Evaluation

M.G. Srinivasan, C.A. Kot, and B.J. Hsieh

Argonne National Lab., Argonne, IL, Rept. No. ANL-83-20, 120 pp (Jan 1984)
NUREG/CR-3649

Key Words: Dynamic tests, Testing techniques

The experience with dynamic testing of as-built large civil engineering structures other than nuclear power plant buildings is evaluated. A review of literature on the dynamic testing of a large number of structures formed the basis for this evaluation. Methods of excitation and data analysis for determining dynamic parameters from measured response are evaluated.

84-2593

Instrumenting and Interpreting the Time-Varying Response of Structural Systems

P.L. Walter

Sandia National Labs., Albuquerque, NM 87185, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 393-400, 8 figs, 7 refs

Key Words: Dynamic tests, Testing techniques

The dynamic testing performed on structural systems sometimes lacks specific objectives. In addition, the design of the

measurement system intended to record the resultant data often does not receive adequate attention. This article presents the *rationale* for performing dynamic testing and provides insight for selecting transducers and determining their mounting locations to measure the resultant structural motion.

84-2594

Acceleration Responses of Typical LRU's Subjected to Bench Handling and Installation Shock

H. Caruso and E. Szymkowiak

Westinghouse Electric Corp., Baltimore, MD, Shock Vib. Bull., No. 54, Pt. 1, pp 91-100 (June 1984) 9 figs, 2 tables, 3 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Drop tests (impact tests), Electronic instrumentation

Measurements were made on a typical LRU (line replaceable unit) to determine the levels of shock associated with the bench handling edge-drop tests described in Mil-Std-810C/D. Measurements were also made on three LRU's mounted on slide rails to determine the shock resulting from typical seating operations during installation.

84-2595

Small-Scale Dynamic Testing of Electrical Raceway Systems for Nuclear Power Plants

B.K. Pearce

Clemson Univ., Clemson, SC, ISA Trans., 23 (2), pp 45-54 (1984) 7 figs, 4 tables, 8 refs

Key Words: Electric raceways, Supports, Nuclear power plants, Dynamic tests, Model testing

One-third scale models of electrical raceways and their support systems have been constructed to compare the response of a typical rigidly-braced system with that of a proposed flexible support system. An array of instrumentation, including accelerometers, strain gages, and displacement transducers, is used to obtain frequency response data, to determine mode shapes of system components, and to obtain data to validate analytical models of the system.

84-2596

Alternative Shock Characterizations for Consistent Shock Test Specification

T.J. Baca

Sandia National Labs., Albuquerque, NM, Shock Vib. Bull., No. 54, Pt. 2, pp 109-130 (June 1984) 22 figs, 3 tables, 10 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Shock tests, Testing techniques

Mechanical shock environments must be characterized in the most complete manner possible if they are to be successfully simulated in the shock test laboratory. The objective of the research described in this paper is to evaluate three methods of analyzing transient acceleration time histories which represent promising alternatives to shock response spectra as the basis for deriving consistent shock test specifications. These shock analysis techniques include: ranked peaks in the acceleration time history; root-mean-square acceleration as a function of time; and root-mean-square acceleration as a function of frequency.

84-2597

Least Favorable Response of Inelastic Structures

Fashin Craig Chang, T.L. Paez, and Frederick Ju

Univ. of New Mexico, Albuquerque, NM 87131, Shock Vib. Bull., No. 54, Pt. 2, pp 143-153 (June 1984) 4 figs, 11 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Least favorable response method, Testing techniques

In the design of a structural system, a test input is sought to conservatively represent an ensemble of measured field inputs. When a structure survives the test input, it is assumed that it would survive the field inputs. The method of shock response spectra is a technique for specifying conservative test inputs, but it has some disadvantages. In this investigation a technique is developed for the specification of test inputs. It is based on the method of least favorable response, and it overcomes some of the shortcomings of the method of shock response spectra.

DIAGNOSTICS

(Also see Nos. 2402, 2579)

84-2598

Stochastic Aspects of Two-Dimensional Vibration Diagnostics

I. Pazsit, O. Gloeckler, and M. Antonopoulos-Domis

Kozponti Fizikai Kutato Intezet, Budapest, Hungary, Rept. No. KFK1-1983-41
DE83704574

Key Words: Diagnostic techniques, Nuclear reactor components, Stochastic processes

Two-dimensional stochastic vibrations of a particle, representing lateral damped forced oscillations of a reactor control rod are simulated by generating random force components and integrating the equations of motion. How various statistical descriptors of the motion such as trajectory pattern, displacement components spectra and APD functions depend on the characteristics of the driving force for both stationary and non-stationary cases is investigated.

84-2599

Precision Measurement of Torsional Oscillations Induced by Gear Errors

S.L. Shmuter
Manufacturing Process Lab., Ford Motor Co., Dearborn, MI, Shock Vib. Bull., No. 54, Pt. 3, pp 77-88 (June 1984) 9 figs, 4 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Diagnostic techniques, Gears, Torsional vibrations, Measurement techniques

An original and practical measuring technique applicable to torsional and gear related systems is described. The technique incorporates a novel angular sensor with resolution of better than 1 part in 10,000 in velocity variations, which is based on commercially available components. A method of establishing dynamic response of a drive train is presented. The method depends on the internal excitation from a gear set itself, thus eliminating any external devices.

84-2600

Vibration Produced by a Single Point Defect on the Inner or Outer Race or Rolling Elements of a Bearing under Radial or Axial Load

P.D. McFadden and J.D. Smith
Dept. of Engrg., Cambridge Univ., England, Rept. No. CUED/C-MECH/TR-34, 23 pp (1983)
PB84-169887

Key Words: Diagnostic techniques, Bearings, Rolling contact bearings

An existing model for the high-frequency vibration produced by a single point defect on the inner race of a rolling element bearing under radial load is extended to describe the vibration produced by defects on the inner or outer races or rolling elements of a bearing under axial or radial load. The model incorporates the effects of bearing geometry, shaft speed, bearing load distribution, transfer function and the exponential decay of vibration.

84-2601

Development of Diagnostic Model for Marine Gas Turbines

P.J. MacGillivray, B.D. MacIssaic, and H.I.H. Saravanamutto
National Defense Forces, Ottawa, Ontario, Canada, ASME Pape⁻ No. 84-GT-221

Key Words: Diagnostic techniques, Gas turbines, Marine engines

A suite of thermodynamic models of the gas turbines on the DDH 280 class destroyers has been developed for onboard diagnostic purposes. The models are based on a fundamental description of the engine components and allow the engineering officer to simulate a variety of faults as a means of duplicating observed measurements.

84-2602

Instrument Failure Detection in Nonlinear Systems

J.L. Tylee and J.E. Purviance
EG and G Idaho, Inc., Idaho Falls, ID, Rept. No. EGG-M-05183, CONF-831235-3, 12 pp (1983) (IEEE Conf. on Decision Control, 22nd, San Antonio, TX, Dec 14, 1983)
DE84005306

Key Words: Failure detection, Instrumentation

A simple approach to detecting instrument failures in dynamic systems described by nonlinear continuous differential equations is presented and evaluated. The method uses an extended Kalman filter to generate an innovations (or residuals) vector. Threshold crossing checks on the mean and variance of elements in this vector are used to ascertain existence of failure. The approach is demonstrated using data from a nuclear reactor.

84-2603

Detection and Sizing of Underbead Cracks Using Ultrasonic Nondestructive Examination

J.D. Scarbrough and W.M. Wierzbicki

E.I. duPont de Nemours and Co., Aiken, SC, Rept. No. DPSPU-82-30-11, 15 pp (1984)

DE83012205

Key Words: Failure detection, Crack detection, Welded joints, Joints (junctions), Ultrasonic techniques

Ultrasonic nondestructive examination will detect three mil deep underbead cracks in welds joining thin walled iridium hemishells. A correlation was developed to relate the amplitude of the signal reflected from the crack with crack wall area. The observed cracks occur in the weld underbead in the arc taper area during encapsulation of exp 238 PuO sub 2 pellets for thermoelectric generators used in deep space exploration.

BALANCING

84-2604

Heuristic Optimization in the Balancing of High Speed Rotors

J.L. Yang, F.H. Chu, and Ting W. Lee

RCA Astro-Electronics, Princeton, NJ 08540, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 163-169 (June 1984) 4 figs, 4 tables, 15 refs

Key Words: Balancing techniques, Dynamic balancing, Rotors, Flexible rotors

A new approach to the dynamic balancing of flexible rotors is presented. The unbalance of a rotor is treated as a combination of a number of discrete unbalancing components, which are identified and subsequently removed using an effective heuristic optimization technique. The method allows the treatment of nonlinear rotor response and design constraints. A specific example is used to illustrate the approach and results are compared with the ones obtained using another optimum balancing technique.

MONITORING

84-2605

Real-Time Flutter Analysis

R. Walker and N.Gupta

Integrated Systems, Inc., Palo Alto, CA, Rept. No. ISI-24, NASA-CR-170412, 126 pp (Mar 1984)

N84-20512

Key Words: Monitoring techniques, Flutter, Real time technique

The important algorithm issues necessary to achieve a real time flutter monitoring system; namely, the guidelines for choosing appropriate model forms, reduction of the parameter convergence transient, handling multiple modes, the effect of over parameterization, and estimate accuracy predictions, both online and for experiment design are addressed. An approach for efficiently computing continuous-time flutter parameter Cramer-Rao estimate error bounds were developed.

84-2606

A Calibration and Estimation Filter for Multiply Redundant Measurement Systems

A. Ray and M. Desai

The Charles Stark Draper Lab., Inc., Cambridge, MA 02139, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 149-156 (June 1984) 4 figs, 18 refs

Key Words: Monitoring techniques, Failure detection, Calibrating

An adaptive filter has been developed for calibration and estimation in multiply redundant measurement systems. The filter is structured in the framework of a fault detection and isolation methodology where the decisions are made on the basis of consistencies among all redundant measurements. The consistent measurements are calibrated on-line to compensate for their errors.

84-2607

A Modern Condition Monitoring and Gas Turbine Control System

D.H. Geer, D. Johnson, and J.A. Pilcher

General Electric Co., Schenectady, NY, ASME Paper No. 84-GT-220

Key Words: Monitoring techniques, Gas turbines

This new generation of plant remote control and monitoring equipment gives plant personnel the tools to establish new standards for availability and optimized performance. It will help them to keep their plant under better control, quickly find the cause of any outage, and do a better job of maintenance planning.

84-2608
Simulation and Analysis of Machinery Fault Signals
M.F. White
The Ship Res. Inst. of Norway, Postbox 4125, Valentinlyst, N-7001 Trondheim, Norway, J.Sound Vib., 93 (1), pp 95-116 (Mar 8, 1984) 22 figs, 1 table, 7 refs

Key Words: Monitoring techniques, Simulation, Mathematical models

Condition monitoring systems are used for the detection of incipient failure and the diagnosis of the nature of faults in operating machinery. Many types of faults produce vibration signals which are impulsive in nature and which may be buried in background noise. A method is described for simulating this type of signal and modeling the various stages of incipient failure. Statistical and spectral analysis are used to describe the fault development.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

(Also see No. 2578)

84-2609
A Further Look at Newmark, Houbolt, Etc., Time-Stepping Formulae
W.L. Wood
Dept. of Mathematics, Univ. of Reading, UK, Intl. J. Numer. Methods Engrg., 20 (6), pp 1009-1017 (June 1984) 10 refs

Key Words: Equations of motion, Integration methods

Methods for numerical integration of vibration equations are examined from the point of view of various groupings of the independent equations involved. New forms are presented for the general three-parameter method introduced by Zienkiewicz. Some new one-step methods are introduced; these are of great practical importance because of the ease with which the size of time step can be changed.

84-2610
On the Solution of Approximated Systems When Using Reduced Component Modes
K.F. Martin and K.H. Ghlaim
Univ. of Wales Inst. of Science and Tech., King Edward VII Avenue, Cardiff CF1 3NU, UK, Earthquake Engrg. Struc. Dynam., 12 (3), pp 417-426 (May/June 1984) 2 tables, 10 refs

Key Words: Component mode analysis, Matrix reduction methods, Approximation methods

The work described in this paper relates to the computation of vibrational characteristics of a system which consists of components connected together elastically. The vibrational characteristics of each component are known and these are used via matrix manipulation to find the system characteristics. This particular paper confines itself to examining the matrix manipulation in detail.

84-2611
An Objective Error Measure for the Comparison of Calculated and Measured Transient Response Histories
T.L. Geers
Lockheed Palo Alto Res. Lab., Palo Alto, CA, Shock Vib. Bull., No. 54, Pt. 2, pp 99-107 (June 1984) 7 figs, 7 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Error analysis, Transient response

A simple error measure is proposed for the objective comparison of a calculated transient response history with its measured counterpart. The measure assigns a single numerical value to the discrepancy between the two histories over a specified comparison period. Computation of the measure involves the integration in time of squares and/or products of the calculated and measured histories. Representative results are shown for both idealized and actual response histories.

84-2612
Reanalysis of Continuous Dynamic Systems with Continuous Modifications
Bo Ping Wang, Y. Okada, and W.D. Pilkey
Univ. of Texas at Arlington, Box 19023, Arlington, TX 76019, Shock Vib. Bull., No. 54, Pt. 3, pp 35-42 (June 1984) 4 figs, 1 table, 6 refs (Proc. Shock Vib.

Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Structural modification techniques, Beams

Formulations are presented for the efficient analysis of dynamic systems with discrete and continuous local modifications. It is assumed that the original (unmodified) system has been analyzed by a transfer matrix method with appropriate response information saved. The effect of introducing modifications can then be determined efficiently using a reanalysis procedure. The proposed technique is applied to a beam type structure.

84-2613

Discrete Modifications to Continuous Dynamic Structural Systems

Y. Okada, Bo Ping Wang, and W.D. Pilkey

Ibaraki Univ., Hitachi, Japan, Shock Vib. Bull., No. 54, Pt. 3, pp 29-34 (June 1984) 4 figs, 3 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Structural modification techniques

The problem of introducing discrete elements such as springs or masses to continuous dynamic systems is considered. A method is developed for the efficient analysis of such modified systems. After a transfer matrix analysis of the original system, appropriate transfer matrices are condensed and stored. Then the effect of the discrete modifications is introduced. The proposed technique is applied to a helicopter model.

STATISTICAL METHODS

84-2614

A Computer Method for Simulating Service Loads

M.K. Abdelhamid and K.G. McConnell

Iowa State Univ., Ames, IA 50011, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15,1984, Montreal, Canada, pp 621-627, 4 figs, 8 refs

Key Words: Stochastic processes, Simulation, Fatigue life, Computer-aided techniques

A recently presented study addresses the problem of analyzing field data that are best characterized as nonstationary stochastic signals. The method of analysis hypothesizes that the *nonstationary* signal consists of two stationary signals, which belong to different populations, occurring consecutively according to a suitable probabilistic model. A simulation method is presented that uses the results of the analysis method to create a sequence that simulates the statistical characteristics of the nonstationary field data. This simulation method is designed to be efficiently implemented on a general purpose computer of any size, including micros.

84-2615

A Hardware Oriented Method for Simulating Service Loads

M.K. Abdelhamid and K.G. McConnell

Iowa State Univ., Ames, IA 50011, Intl. Congress on Exptl. Mechanics, Proc. of the 5th, Soc. of Exptl. Stress Analysis, June 10-15, 1984, Montreal, Canada, pp 613-620, 8 figs, 7 refs

Key Words: Stochastic processes, Simulation, Excitation

A recently presented study addresses the problem of analyzing field data that are best characterized as nonstationary stochastic signals. The method of analysis hypothesizes that the nonstationary signal consists of two stationary signals, *which belong to different populations, occurring* consecutively according to a suitable probabilistic model. A simulation method is presented which uses the results of the analysis method to create a sequence that simulates the statistical characteristics of the nonstationary field data. This simulation method is designed to be efficiently generated via a simple digital electronic circuit and to be available at a high sampling rate.

OPTIMIZATION TECHNIQUES

84-2616

Computer-Aided Optimal Design of Constrained Dynamic Systems

P. Krishnaswami

Ph.D. Thesis, Univ. of Iowa, 140 pp (1983)
DA8407765

Key Words: Optimization, Computer-aided techniques, Design techniques

A *computer-oriented* method is developed for optimal design of planar, constrained dynamic systems. The system

equations of motion are automatically identified and a minimal set of independent generalized coordinates is identified. A set of differential equations for state sensitivity is obtained by direct differentiation of the equations of motion. These sensitivity equations and the equations of motion are integrated simultaneously to obtain the system response as well as the state sensitivity matrices.

COMPUTER PROGRAMS

84-2617

Static and Dynamic Structural-Sensitivity Derivative Calculations in the Finite-Element-Based Engineering Analysis Language (EAL) System

C.J. Camarda and H.M. Adelman

NASA Langley Res. Ctr., Hampton, VA, Rept. No. L-15659, NASA-TM-85743, 80 pp (Mar 1984)

N84-20880

Key Words: Computer programs, Finite element technique

The implementation of static and dynamic structural-sensitivity derivative calculations in a general purpose, finite-element computer program denoted the Engineering Analysis Language (EAL) System is described. Derivatives are calculated with respect to structural parameters, specifically, member sectional properties including thicknesses, cross-sectional areas, and moments of inertia. Derivatives are obtained for displacements, stresses, vibration frequencies and mode shapes, and buckling loads and mode shapes. Three methods for calculating derivatives are implemented (analytical, semianalytical, and finite differences), and comparisons of computer time and accuracy are made. Results are presented for four examples: a swept wing, a box beam, a stiffened cylinder with a cutout, and a space radiometer-antenna truss.

84-2618

A Nonlinear Dynamic Analysis Finite Element Program with an Application to Elevator Counterweight Systems

Horn-Sen Tzou

Ph.D. Thesis, Purdue Univ., 328 pp (1983)

DA8407617

Key Words: Computer programs, Eigenvalue problems, Finite element technique, Time domain method

A general purpose nonlinear dynamic analysis finite element program is developed. The eigenvalue analysis of linear systems and the time-domain integration of linear or nonlinear systems can be performed for the systems modeled by beam elements. The program has the capability of analyzing an elastic system in which there is contact between parts of the system. One application of this program is the study of nonlinear dynamic response of elevator counterweight/frame/guide rail systems subjected to external base excitation. A simplified small-scale physical model has been built and tested to study its dynamic behavior.

84-2619

Accurately Computed Modal Densities for Panels and Cylinders, *Including Corrugations and Stiffeners*

F.W. Williams and J.R. Banerjee

Univ. of Wales Inst. of Science and Tech., Cardiff CF1 3EU, UK, J. Sound Vib., 93 (4), pp 481-488 (Apr 22, 1984) 4 figs, 10 refs

Key Words: Computer programs, Modal analysis, Plates, Panels, Shells, Cylindrical shells

The new computer program VISCAN enables exact modal densities to be computed very economically for any prismatic assembly of isotropic or anisotropic flat plates which are simply supported at their ends and are rigidly connected together along their longitudinal edges, so long as bending and in-plane displacements are uncoupled for the anisotropic plates. A description of how VISCAN was developed from the well established program VIPASA is followed by results for flat, corrugated and stiffened panels and for a cylindrical shell, a corrugated cylinder and a stiffened cylinder.

84-2620

User's Manual SIG: A General-Purpose Signal Processing Program

D. Lager and S. Azevedo

Lawrence Livermore National Lab., CA, Rept. No. UCID-19912, 74 pp (Oct 25, 1983)

DE84002678

Key Words: Computer programs, Signal processing techniques, Frequency domain method, Time domain method

SIG is a general-purpose signal processing, analysis, and display program. Its main purpose is to perform manipulations on time- and frequency-domain signals. However, it has been designed to ultimately accommodate other representations for data such as multiplexed signals and complex matrices.

Many of the basic operations one would perform on digitized data are contained in the core SIG package. Out of these core commands, more powerful signal processing algorithms may be built.

84-2621

Generalization of the Subsonic Kernel Function in the S-Plane, with Applications to Flutter Analysis

H.J. Cunningham and R.N. Desmarais

NASA Langley Res. Ctr., Hampton, VA, Rept. No. L-15708, NASA-TP-2292, 39 pp (Mar 1984)

N84-20480

Key Words: Flutter, Computer programs

A generalized subsonic unsteady aerodynamic kernel function, valid for both growing and decaying oscillatory motions, is developed and applied in a modified flutter analysis computer program to solve the boundaries of constant damping ratio as well as the flutter boundary. Rates of change of damping ratios with respect to dynamic pressure near flutter are substantially lower from the generalized-kernel-function calculations than from the conventional velocity-damping (V-g) calculation.

84-2622

Computer-Aided Structural Engineering (CASE) Project. User's Guide. Computer Program for Optimum Dynamic Design of Nonlinear Metal Plates under Blast Loading (CSDOOR)

J.M.Ferritto, R.M. Wamsley, and P.K. Senter

Army Engineer Waterways Experiment Station, Vicksburg, MS, Rept. No. WES-IR-K-84-2, 62 pp (Jan 1984)

AD-A140 053

Key Words: Computer programs, Plates, Blast resistant structures

CSDOOR called X0067 in the Conversationally Oriented Real-Time Programming System (CORPS) library, is useful to perform roped design of metal plates used to form the sides and roofs of blast cells and of metal used as doors-regular and built-up. The program may be used for any structure materials for which the material properties are known but steel is the most commonly used. The program may be used, with limitations, to optimize the design by funding the least-cost structures that satisfies all the design constraints.

84-2623

EURDYN: Computer Programs for the Nonlinear Transient Analysis of Structures Submitted to Dynamic Loading. EURDYN (Release 3); Users' Manual

J.P. Halleux

Commission of the European Communities, Luxembourg, Rept. No. EUR-8357-EN, 162 pp (1983)

PB84-162080

Key Words: Computer programs, Shells, Transient response

EURDYN 01, 02, and 03 are Fortran programs designed for large displacement and large rotation transient dynamic analysis of plane stress, plane strain, and axisymmetric structures, and for the transient dynamic analysis of 3-D thin shells. The updated version of the programs includes several novel features: full large strain capability for 9-node isoparametric elements, generalized array dimensions, introduction of the radial return algorithm for elasto-plastic material modeling, and possible interface capability to a post-processing package including time plot facilities. For each program, the manual gives an overview of the capabilities, explains the input data preparation and solves a test problem.

84-2624

AUTDYN – A Digital Simulation Computer Program for the Handling Dynamics of Passenger Cars – Part 1 (AUTDYN – ein digitales Simulationsrechenprogramm für die Fahrdynamik von Personenkraftwagen – Teil 1)

F. Uffelmann

Kammühlweg 9, 8074 Gaimersheim, Automobiltech Z., 86 (2), pp 41-46 (Feb 1984) 5 figs, 34 refs

(In German)

Key Words: Computer programs, Automobiles, Ride dynamics

A new vehicle dynamics simulation model – AUTDYN – has been developed which imposes no restrictions on the vehicle body in terms of degrees of freedom of movement, distribution of mass or torsional softness between the axles. The special advantage of the model is its exact reproduction of the kinematics and elastokinematics of the wheel suspension. Spring and shock-absorber action are simulated to any desired nonlinear functions, the rotating wheels and suspension components are given appropriate masses and moments of inertia, the tires are resilient in the vertical and lateral directions, and irregularities in the road surface can be simulated as required. Numerous other details allow for all normal driver inputs.

84-2625
Solutions to Structural Dynamics Problems
G. Morosow
Martin Marietta Corp., Denver, CO, Shock Vib. Bull., No. 54, Pt. 1, pp 77-82 (June 1984) 4 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Computer programs, Reviews

Computer programming is reviewed from its start in the early fifties. The characteristics of modular and fixed programming are described and compared.

GENERAL TOPICS

TUTORIALS AND REVIEWS

84-2626
Where is the Real Literature on Airblast and Ground Shock?
W.E. Baker
Southwest Res. Inst., San Antonio, TX, Shock Vib. Bull., No. 54, Pt. 1, pp 83-86 (June 1984) 12 refs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Ground shock, Air blast

Potential literature sources on airblast and ground shock falling into general classes (books, periodicals, technical reports, and proceedings of symposia and colloquia) are presented. For report literature a number of governmental agencies are listed.

CRITERIA, STANDARDS, AND SPECIFICATIONS

84-2627
Tailoring Initiatives for MIL-STD-810D - Environmental Test Methods and Engineering Guidelines
D.L. Earls
Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, Shock Vib. Bull., No. 54, Pt. 1, pp 87-90 (June 1984) (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Standards and codes, Testing techniques

Previous editions of MIL-STD-810 emphasized environmental qualification tests conducted at worldwide climatic and dynamic environmental extremes. The tests were essentially rigid worse case requirements, presented in a cookbook style, offering few alternatives for individual applications. In contrast, new MIL-STD-810D provides engineering tasks to determine life cycle environmental histories of equipment so that tests can be formulated and tailored to the individual equipment applications.

84-2628
Impact of 810D on Dynamic Test Laboratories
A.J. Curtis
Hughes Aircraft Co., El Segundo, CA, Shock Vib. Bull., No. 54, Pt. 1, pp 101-112 (June 1984) 15 figs (Proc. Shock Vib. Symp., Oct 18-20, 1983, Jet Propulsion Lab., Pasadena, CA. Spons. SVIC, Naval Res. Lab., Washington, DC)

Key Words: Standards and codes, Testing techniques

An informal assessment of the impact of MIL-STD-810D, Environmental Test Methods and Engineering Guidelines, are presented. Figures are included.

84-2629
A Dynamic-Test Procedure for Improving Seismic Qualification Guidelines
C.W. deSilva
Carnegie-Mellon Univ., Pittsburgh, PA 15213, J. Dynam. Syst., Meas. Control, Trans. ASME, 106 (2), pp 143-148 (June 1984) 5 figs, 8 refs

Key Words: Standards and codes, Seismic tests, Dynamic tests, Qualification tests

Several shortcomings of available standards, regulatory guides, and review plans for seismic qualification testing are identified. A rational test nomenclature is proposed. A standard test is developed by optimizing an appropriate test severity measure function. The standard test is a rectilinear test that is equivalent to the three-degree-of-freedom test with uncorrelated excitations, recommended in IEEE-Std. 344.

AUTHOR INDEX

CALENDAR

DECEMBER 1984

3-5 International Conference on Noise Control Engineering [International Institute of Noise Control Engineering] Honolulu, Hawaii *(INTER-NOISE 84 Secretariat, Noise Control Foundation, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719)*

3-6 Truck and Bus Meeting and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

9-14 ASME Winter Annual Meeting [ASME] New Orleans, LA *(ASME Hqs.)*

13-14 Underwater Acoustic Calibration and Measurements, Bracknell, Berks. UK *(L. Lipscombe, db Instrumentation Ltd., Eastern Road, Aldershot, England)*

28-31 International Conference on Applied Numerical Modeling/Computational Mechanics, Tainan, Taiwan, ROC *(S.Y. Wang, Engineering, University of Mississippi, University, MS 38677)*

JANUARY 1985

22-24 Annual Reliability and Maintainability Symp. [IES] Philadelphia, PA *(IES Hqs.)*

28-31 3rd International Modal Analysis Conference [Union College] Orlando, FL *(Ms. Rae D'Amelio, Union College, Wells House, 1 Union Ave., Schenectady, NY 12308 - (518) 370-6288)*

29-Feb 1 International Conference on Nondestructive Evaluation in Nuclear Industry, Grenoble, France *(J.P. Launay, COFREND, 32 Boulevard de la Chapelle, 75880 Paris Cedex 18, France)*

FEBRUARY 1985

25-Mar 1 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1985

18-21 30th International Gas Turbine Conference and Exhibit [ASME] Houston, TX *(Intl. Gas Turbine Ctr., Gas Turbine Div., ASME, 4250 Perimeter Park South, Suite 108, Atlanta, GA 30341 - (404) 451-1905)*

APRIL 1985

1-3 2nd International Symposium on Aeroelasticity and Structural Dynamics [Deutsche Gesellschaft für Luft- und Raumfahrt e.V.] Technical University of Aachen, Germany *(Symposium Organizing Secretariate, Deutsche Gesellschaft für Luft- und Raumfahrt, Godesberger Allee 70, D-5300 Bonn 2, W. Germany)*

8-12 Acoustical Society of America, Spring Meeting [ASA] Austin, TX *(ASA Hqs.)*

15-17 Institute of Acoustics Spring Conference [IOA] York University, UK *(IOA, 25 Chambers St., Edinburgh EH1 1HU, UK)*

15-19 2nd Symp. on Interaction of Non-Nuclear Munitions with Structures [Tyndall AFB, FL; Eglin AFB, FL; Kirtland AFB, NM] Panama City Beach, FL *(Ms. L.C. Clouston, Registrar, P.O. Box 1918, Eglin AFB, FL 32542 - (904) 882-5614)*

22-26 International Symposium on Acoustical Imaging, The Hague, The Netherlands *(J. Ridder, P.O. Box 5046, 2600 GA Delft, The Netherlands)*

29-May 3 31st Annual Technical Meeting and Equipment Exposition [IES] Las Vegas, NM *(IES Hqs.)*

MAY 1985

6-8 4th International Symposium on Hand-Arm Vibration [Finnish Inst. of Occupational Health] Helsinki, Finland *(I. Pyykko, Inst. of Occupational Health, Laajaniityntie 1, 01620, Vantaa 62, Finland)*

6-9 American Society of Lubrication Engineers, 40th Annual Meeting [ASLE] Las Vegas, NY *(ASLE Hqs.)*

JUNE 1985

3-5 NOISE-CON 85 [Institute of Noise Control Engineering and Ohio State University] Columbus, OH *(NOISE-CON 85, Dept. of Mech. Engrg., Ohio State Univ., 206 W. 18th Ave., Columbus, OH 43210 - (614) 422-1910)*

JULY 1985

2-4 Ultrasonics International '85, Kings College, London *(Z. Novak, Ultrasonics, P.O. Box 63, Westbury House, Bury St., Guildford, Surrey GU2 5BH, England)*

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AHS: American Helicopter Society
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Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics
1633 Broadway
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASLE: American Society of Lubrication Engineers
838 Busse Highway
Park Ridge, IL 60068

ASME: American Society of Mechanical Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
United Engineering Center
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
67 Alexander Dr.
Research Triangle Park, NC 27709

SAE: Society of Automotive Engineers
400 Commonwealth Dr.
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Dr.
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Laboratory
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Washington, D.C. 20375

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Unsolicited articles are accepted for publication in the **Shock and Vibration Digest.** Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

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- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, issue number, and pages for journals; publisher for books
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A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).
2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addison-Wesley (1955).
3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Dev. (1962).
4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).
5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).
6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).
7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

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